



Exploring AIRS and other Atmospheric Data with Giovanni

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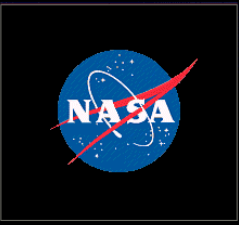
GES DISC, Code 610.2, GSFC

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Outline

- About Giovanni
- Current AIRS Giovanni functionalities
- Exploring events with Giovanni instances:
 - Ozone hole
 - Saharan dust transport
 - Hurricane Katrina
- Statistics issues: averaging, biases, etc.
- A-Train Data Depot
- Future of AIRS in Giovanni
- Soliciting Feedback



GES-DISC Interactive Online Visualization and Analysis Infrastructure (Giovanni)

- With Giovanni and a few mouse clicks, one can easily obtain information on atmosphere state from around the world
- No need to learn data formats and to retrieve and process data
- Assess various phenomena interactively
- Try various combinations of parameters measured by different instruments
- All the statistical analysis is done via a regular web browser

<http://giovanni.gsfc.nasa.gov/>

Caution: *Giovanni is an exploration tool*



Giovanni

Data Inputs

MLS Aura

OMI Aura

MODIS Aqua

AIRS Aqua

MODIS Terra

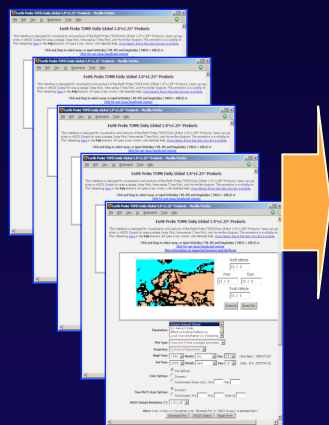
SeaWiFS

TRMM

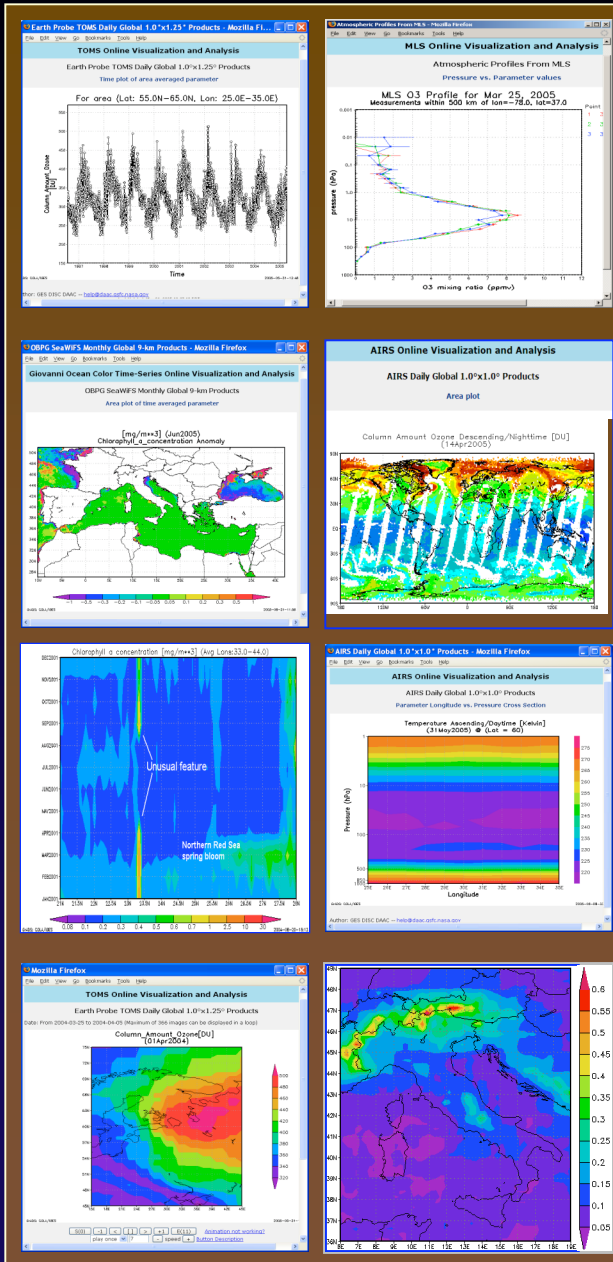
HALOE UARS

TOMS EP Nimbus

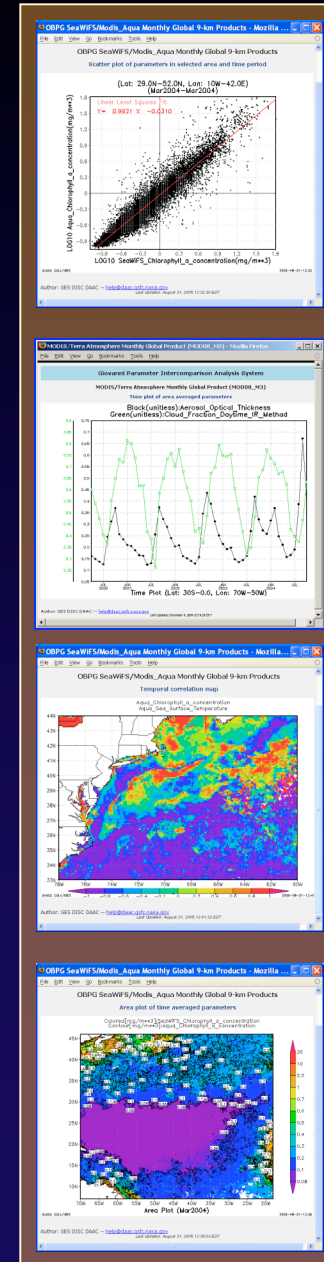
Giovanni Instances



Single Parameter View



Parameter Intercomparison



March 10, 2006

G.Leptoukh, AIRS ST'06, Pasadena

4



AIRS Giovanni

- Currently supports only AIRS Daily Global Level-3 (1 x 1 deg) products with the following parameters:
 - Temperature,
 - Water Vapor Mass Mixing Ratio,
 - Relative Humidity,
 - Column Ozone,
 - Surface Air Temperature,
 - Surface Skin Temperature,
 - Geopotential Heights
 - Surface Pressure
- Limited to Coarse Scale Features
- Need to examine data coverage issues before making conclusions.



AIRS Giovanni Plot Options

Lat-Lon Map, Time-averaged - data values for each data grid are averaged over the user specified time range with interval-weighted average

Time Series, Area-averaged - calculated with area-weighted averaging. For a single point, time series is for the nearest grid point and no averaging or interpolating is performed

Lat-Pressure Cross-section, Lon-averaged - calculated by averaging user selected longitude range with interval-weighted average

Lon-Pressure Cross-section, Lat-averaged - calculated by averaging user selected latitude range with interval-weighted average, weighted by the difference between the sines of the latitude at the northern and southern edges of the grid box

Vertical Profile, Parameter vs. Pressure/Altitude - Averaged over time, latitude or longitude, using interval-weighted average if a time period, latitude or longitude range is selected; a spatial average is performed using area-weighted average if an area is selected



Scenarios



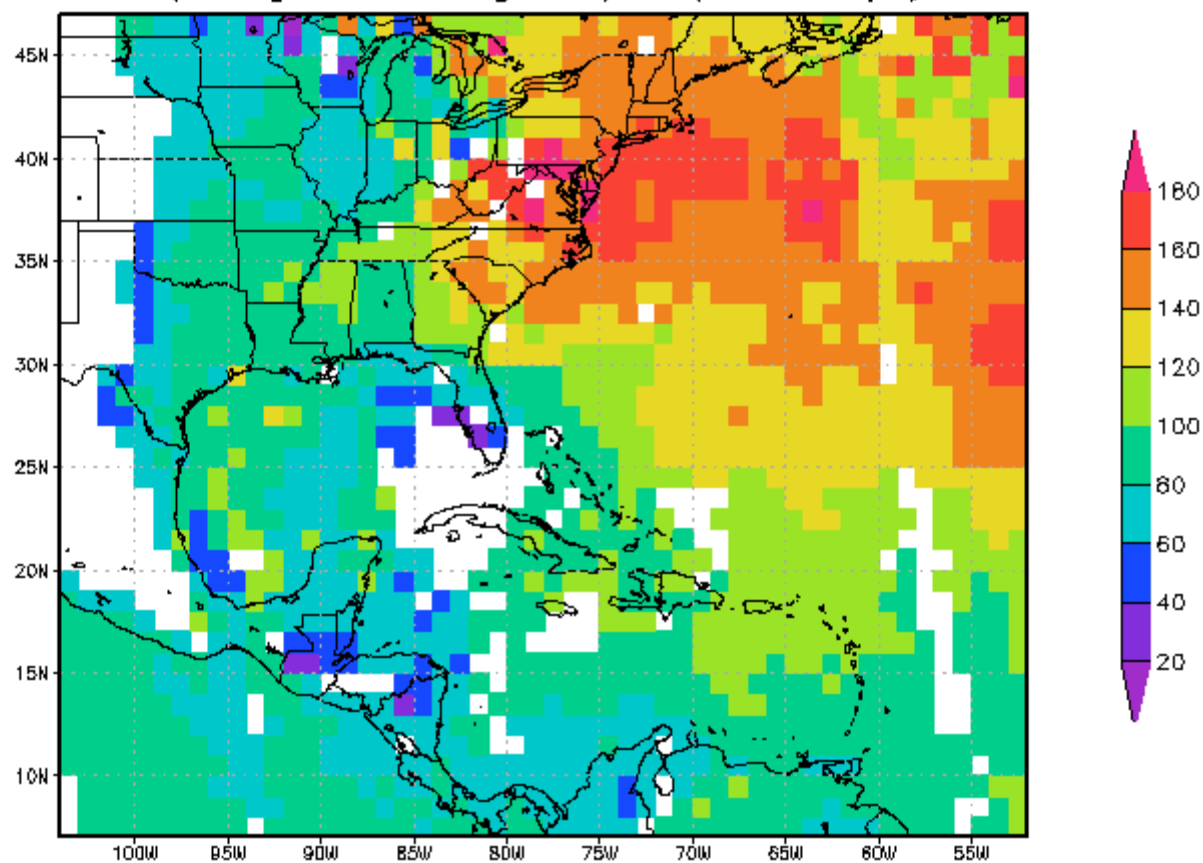
Hurricane Katrina

- Examples of Precipitation, Geopotential Height, for the end of August 2005
- Measurements by OMI, MODIS, and TRMM
- Area maps of Ozone and Surface reflectivity
- Lon-time Hovmoller plot



Pre-Katrina

Daily AIRS Geopotential Height Ascending/Daytime [m]
(25Aug2005–27Aug2005) @ (1000.0 hpa)



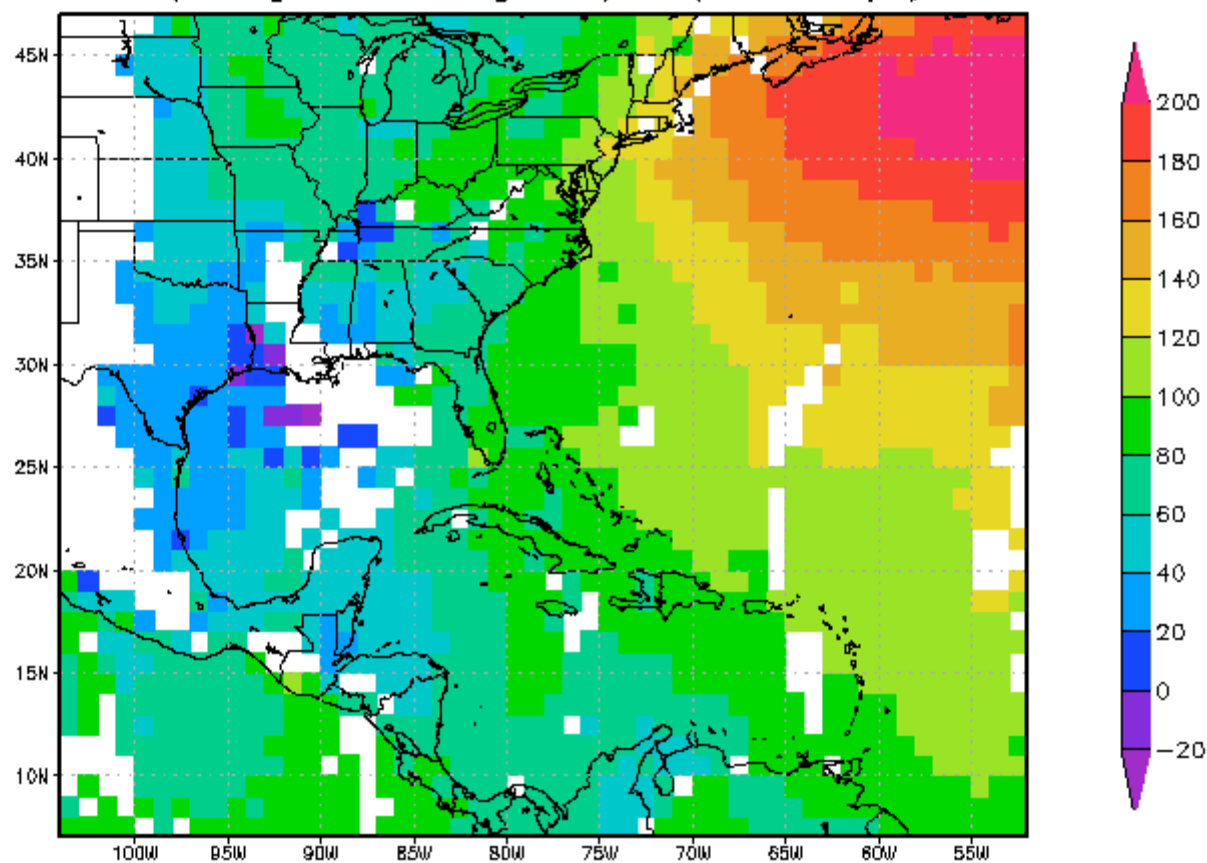
GrADS: COLA/IGES

2006-03-07-18:01



Katrina

Daily AIRS Geopotential Height Ascending/Daytime [m]
(28Aug2005–30Aug2005) @ (1000.0 hpa)

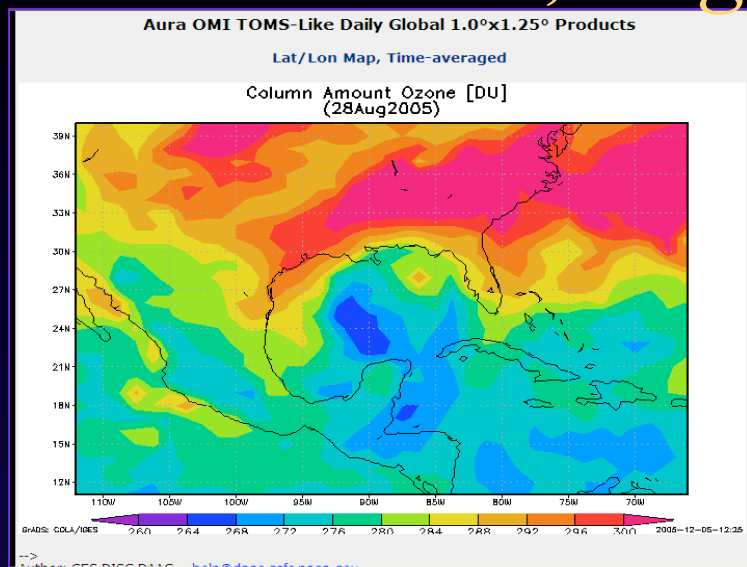


GrADS: COLA/IGES

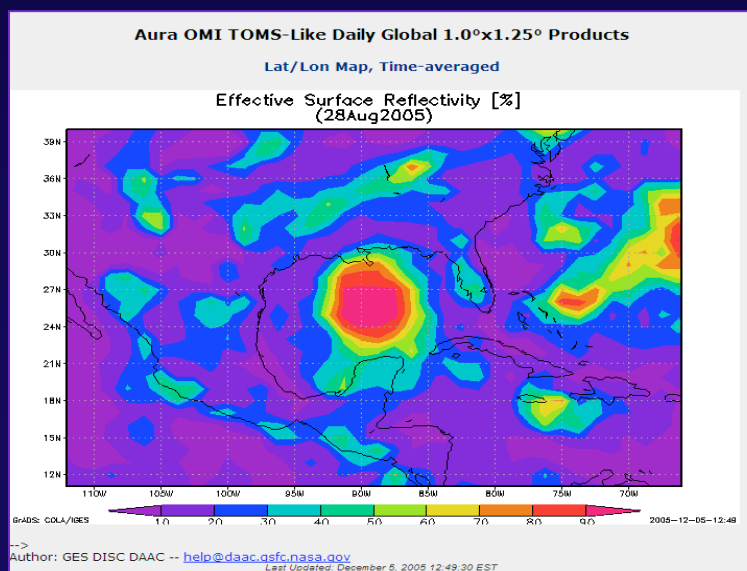
2006-03-07-17:59



Hurricane Katrina, August 28, 2005

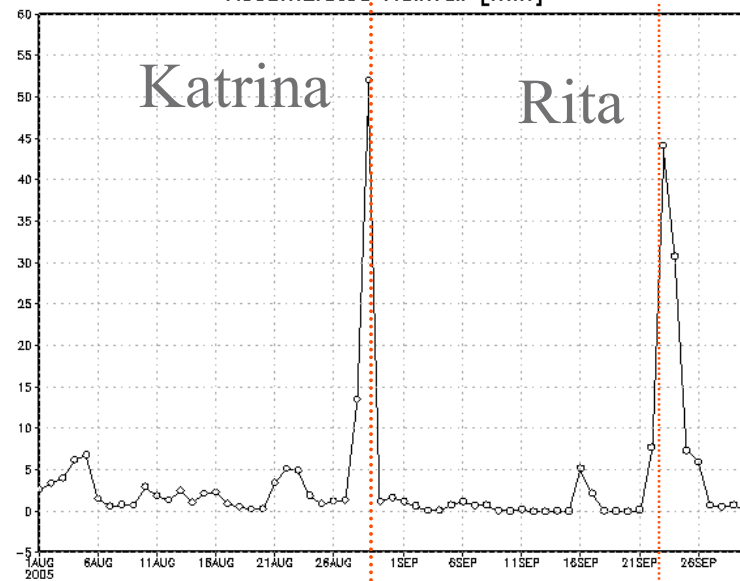


OMI total column ozone (left bottom)

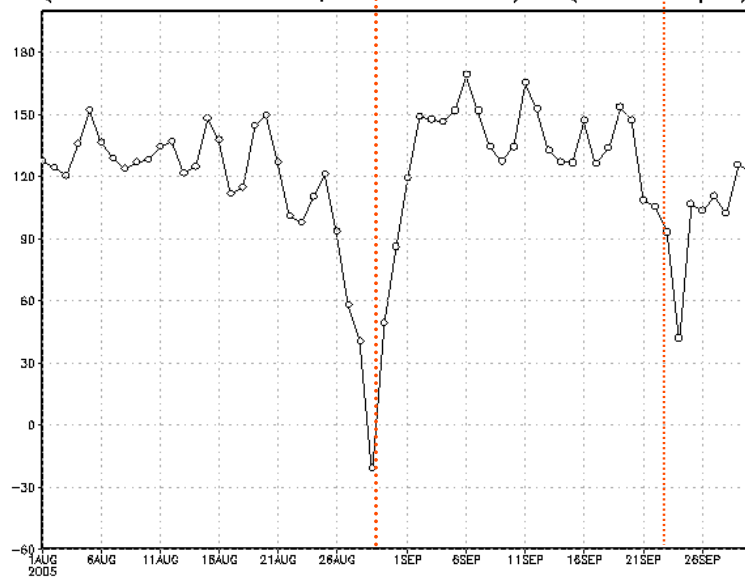


OMI effective surface reflectivity

Daily TRMM 3B42(V6) (Lat: 27.0N-33.0N, Lon: 93W-87W)
Accumulated Rainfall [mm]



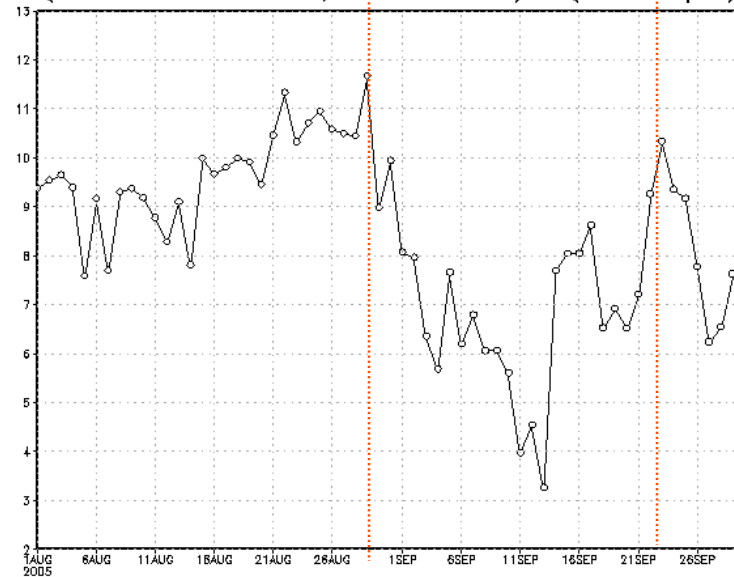
Daily AIRS13 Geopotential Height Ascending/Daytime[m]
(Lat: 27.000N-33.000N, Lon: 93W-87W) @ (1000.0 hpa)



Daily AIRS13 Water Vapor Mass Mixing Ratio Ascending/Daytime[g/kg]
(Lat: 27.000N-33.000N, Lon: 93W-87W) @ (1000.0 hpa)



Daily AIRS13 Water Vapor Mass Mixing Ratio Ascending/Daytime[g/kg]
(Lat: 27.000N-33.000N, Lon: 93W-87W) @ (850.0 hpa)



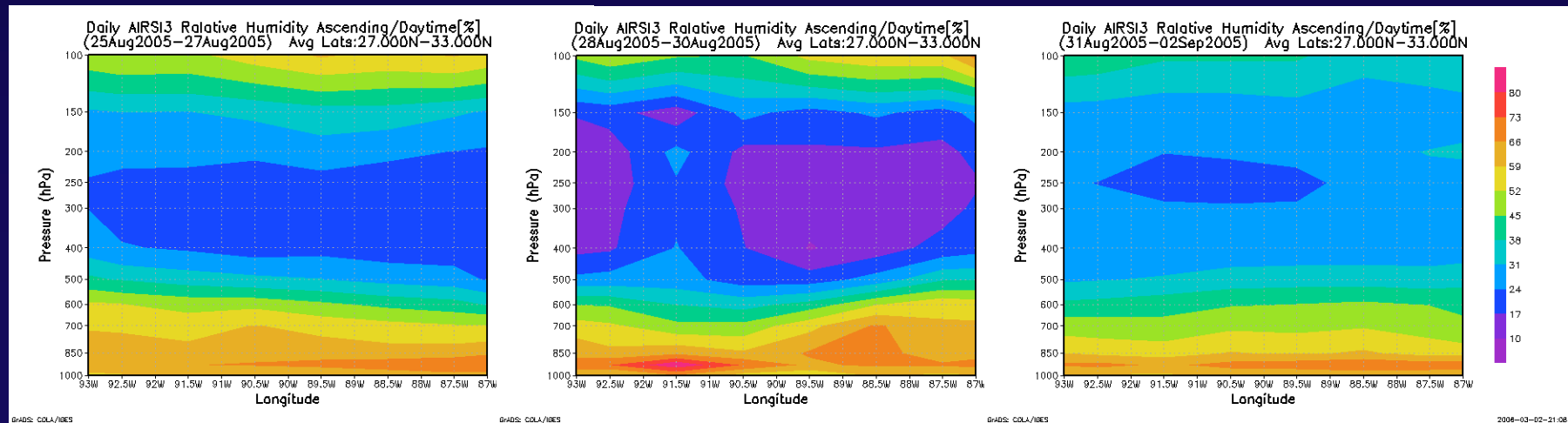
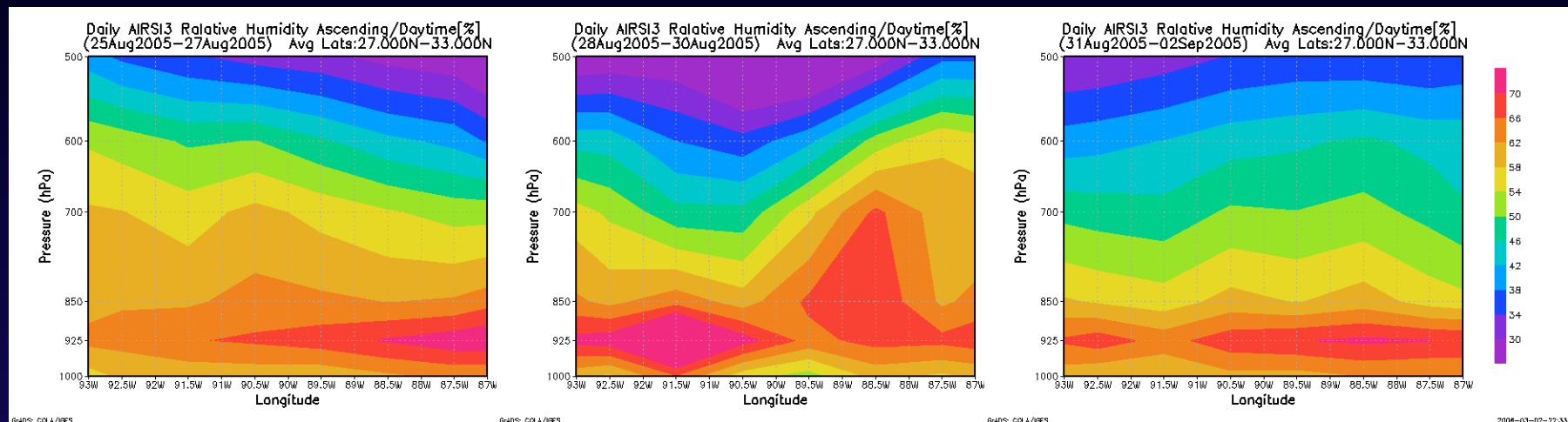
GrADS: COLA/IGES

2006-03-02-20:51 GrADS: COLA/IGES

2006-03-02-20:56



AIRS Relative Humidity before, during, and after Hurricane Katrina



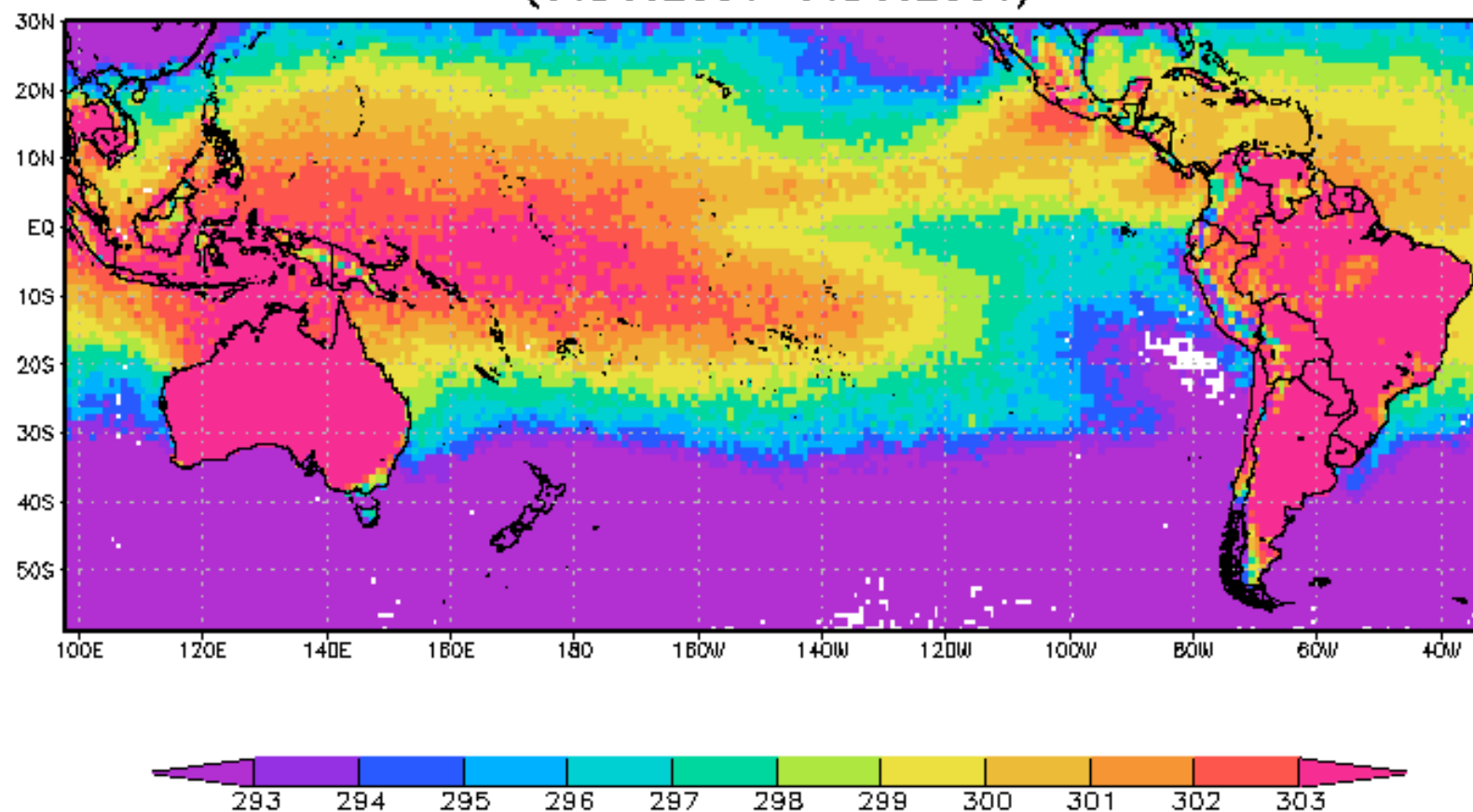


La Niña scenario

- In December 2005, cold ocean temperatures in the equatorial Pacific are clearly seen in the AIRS surface skin temperature data. Compared with December 2004 plot, the 20-22 °C cold tongue is much more pronounced this winter, pointing to a La Niña event.
- La Niña tends to bring wetter than normal conditions across the Pacific Northwest and dryer and warmer than normal conditions across much of the southern tier. During a La Niña year, winter temperatures are warmer than normal in the Southeast and cooler than normal in the Northwest.
- Supporting evidences:
 - the warmer surface air temperature contours (from AIRS retrievals) moved further north this winter than past two winters (refer to the TsfcAir plots);
 - after having a relatively wetter year in Texas last year which has promoted growth of trees and brushes, this warmer and dryer winter has created favorable conditions for wildfire hazards as being reported in the media lately.



Daily AIRS Surface Skin Temperature Ascending/Daytime [Kelvin] (01Dec2004–31Dec2004)

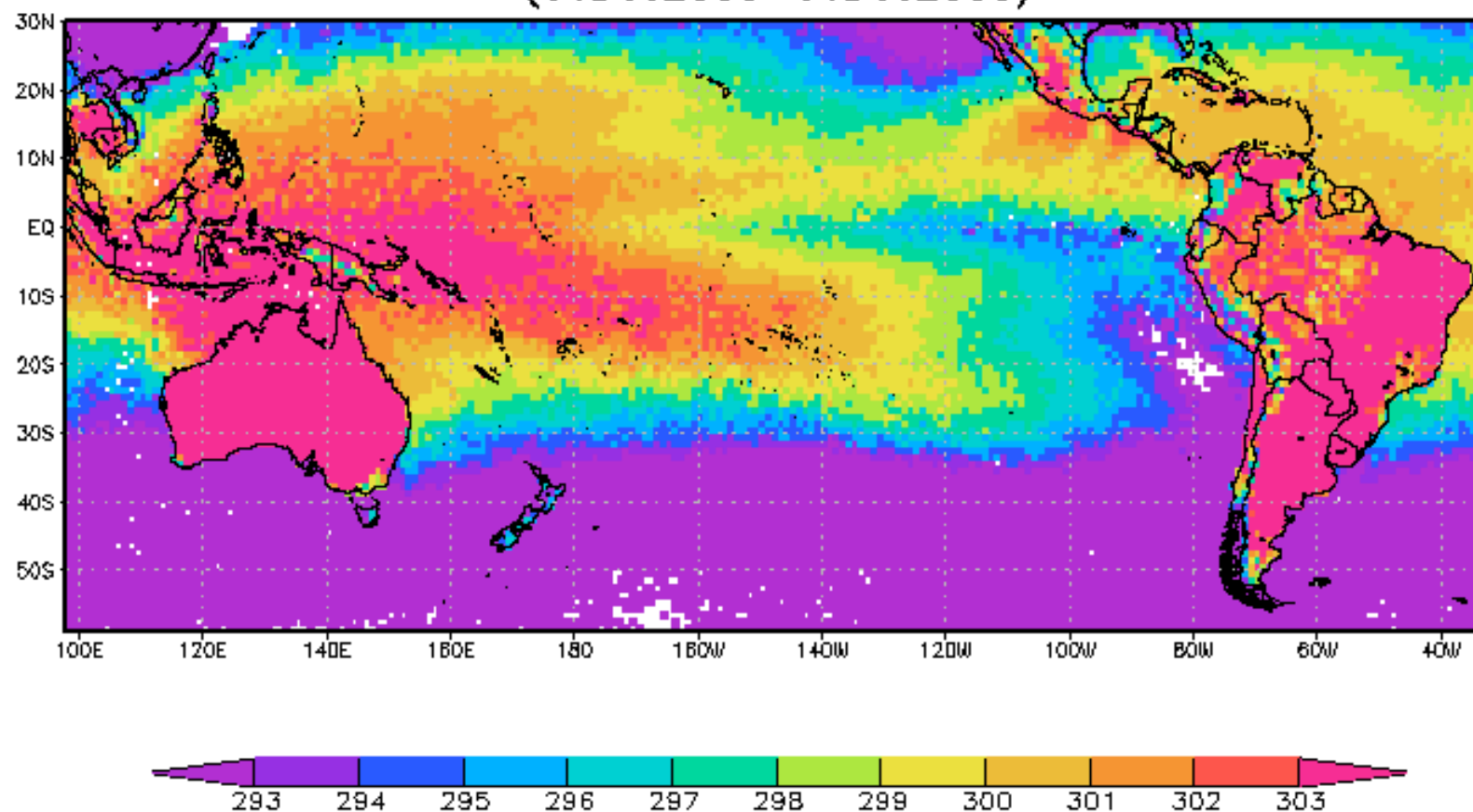


GrADS: COLA/IGES

2006-03-03-10:32



Daily AIRS Surface Skin Temperature Ascending/Daytime [Kelvin] (01Dec2005–31Dec2005)

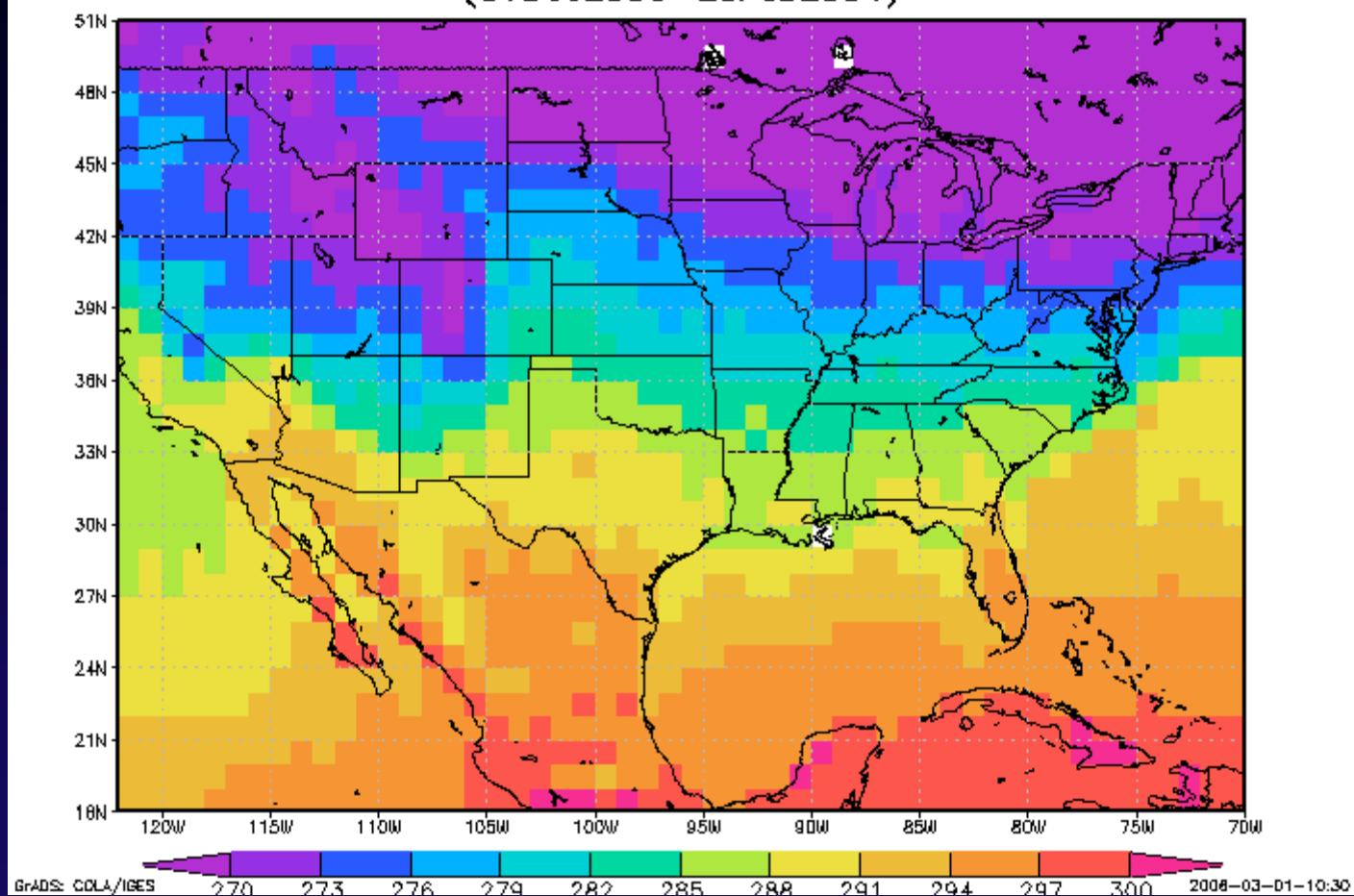


GrADS: COLA/IGES

2006-03-03-10:34

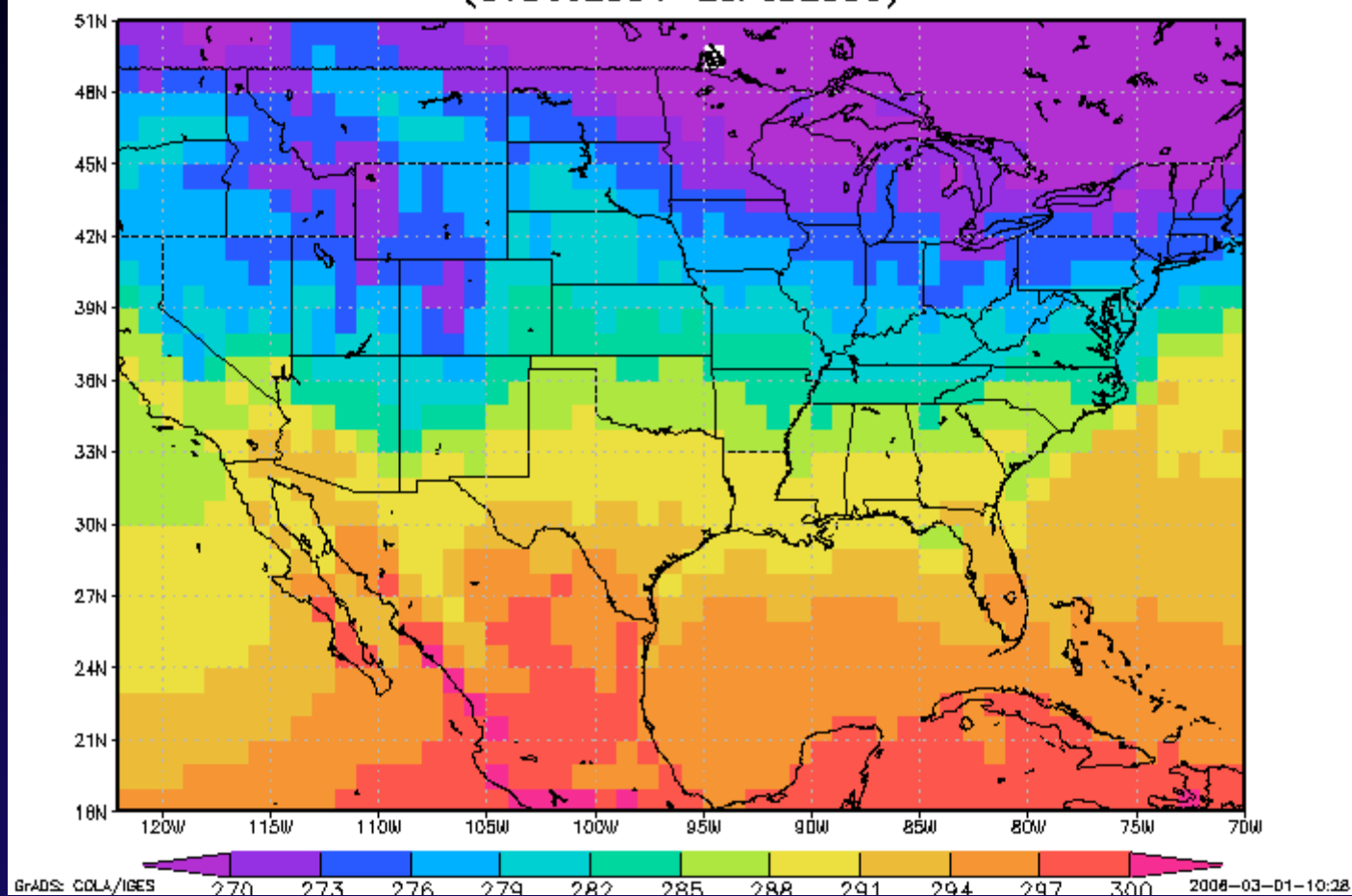


Daily AIRS Surface Air Temperature Ascending/Daytime [Kelvin]
(01Dec2003-20Feb2004)



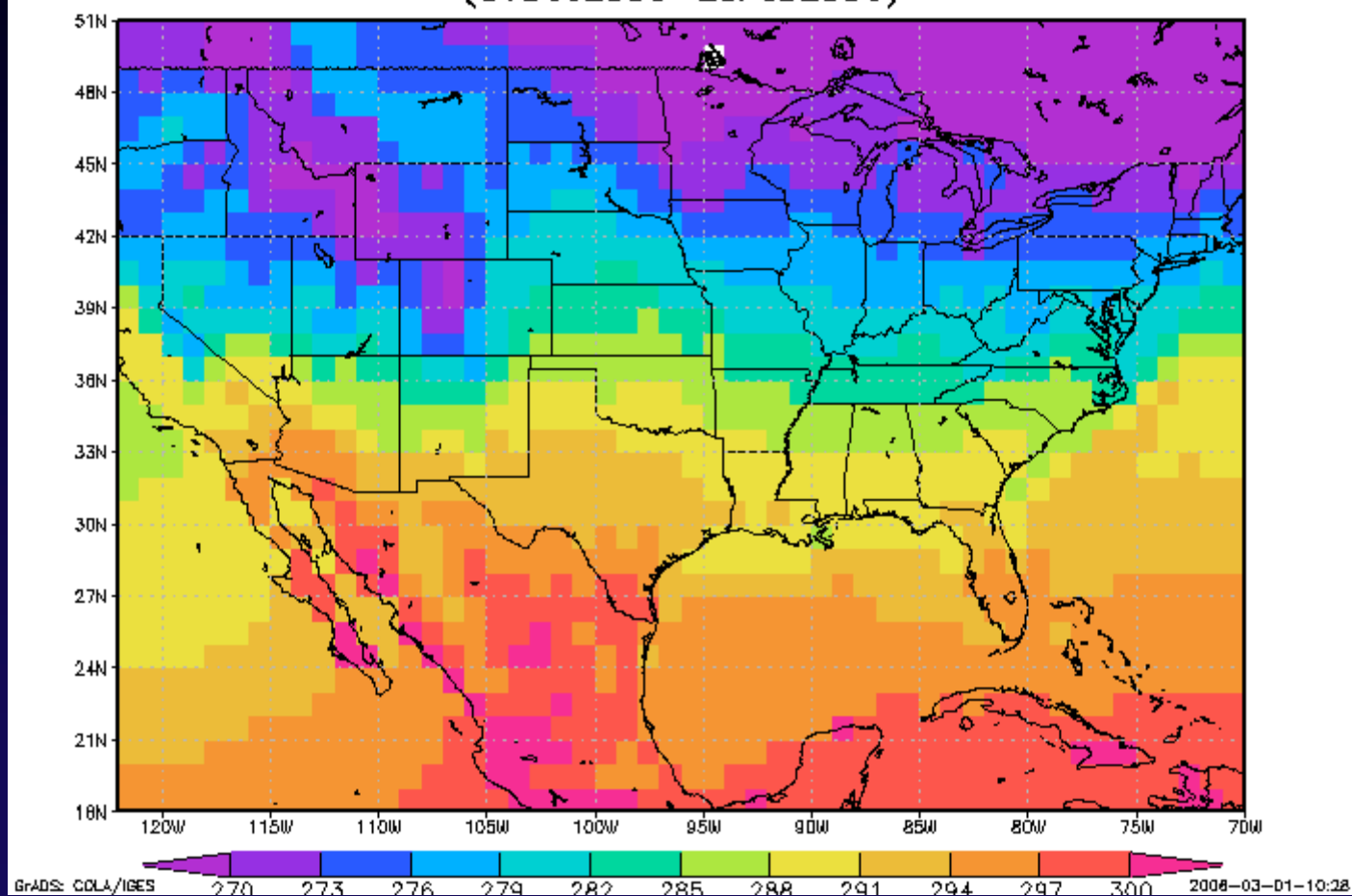


Daily AIRS Surface Air Temperature Ascending/Daytime [Kelvin]
(01Dec2004-20Feb2005)





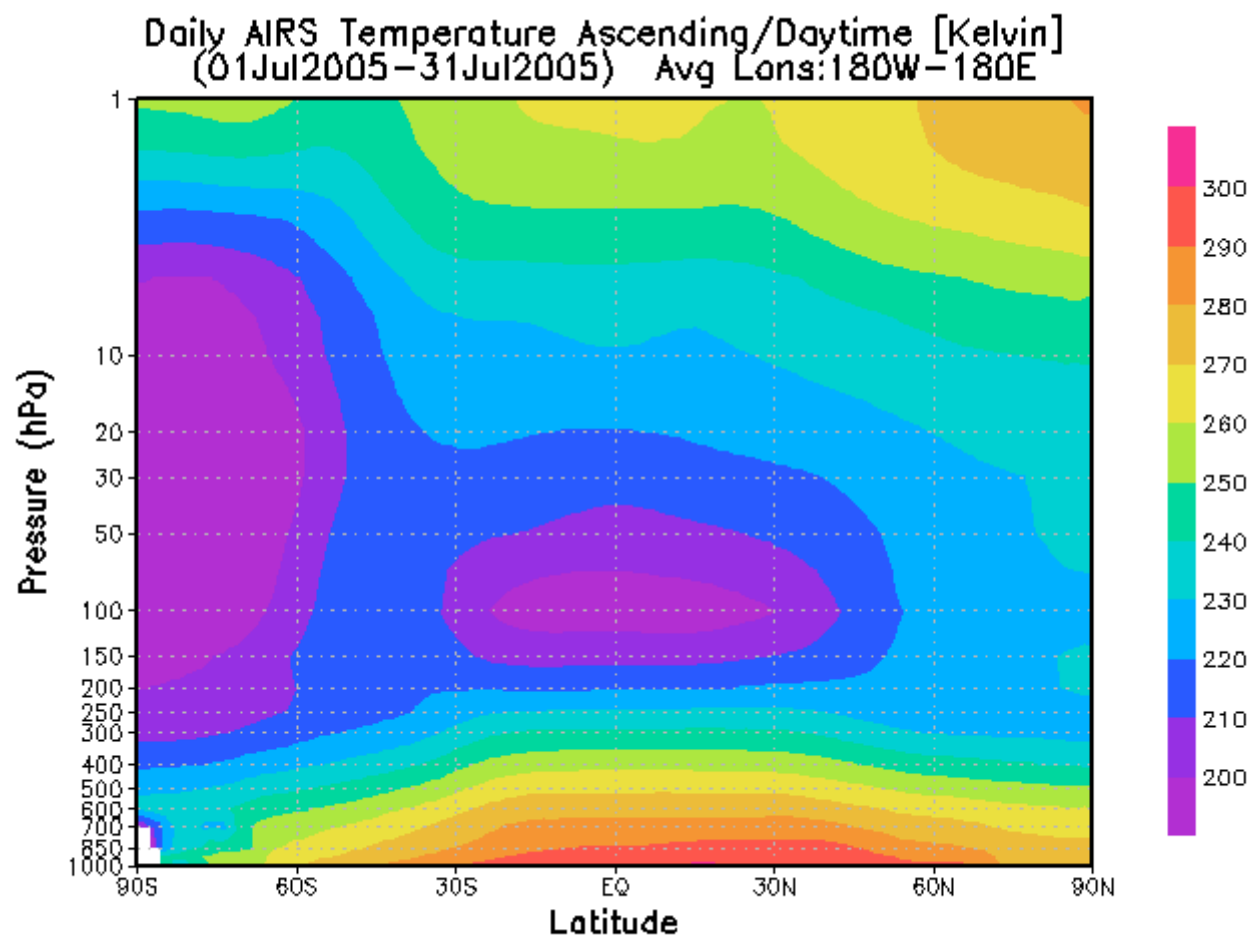
Daily AIRS Surface Air Temperature Ascending/Daytime [Kelvin]
(01Dec2005-20Feb2006)





Zonal Mean of Temperature Cross-sections

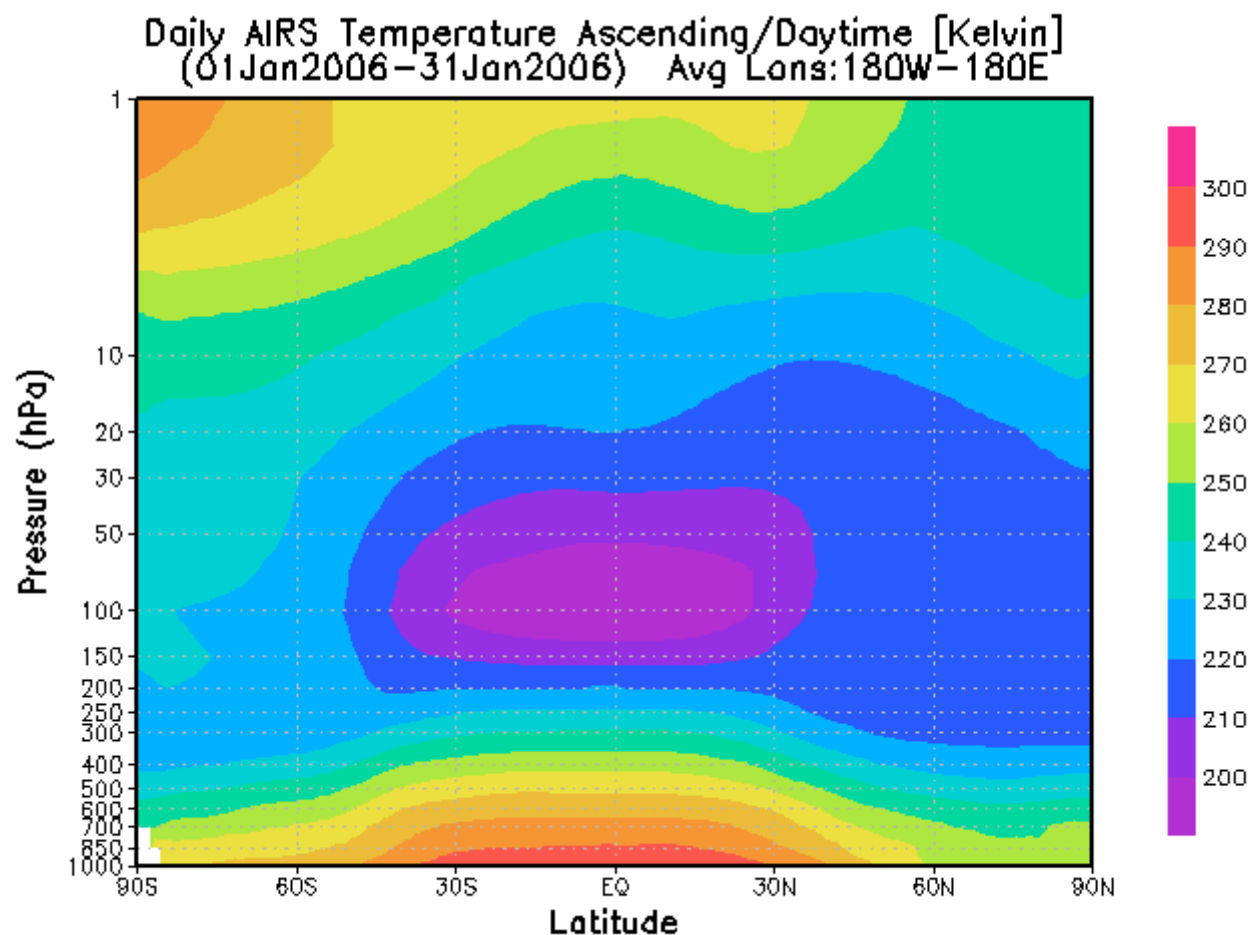
- Throughout a year, tropospheric temperature is horizontally uniform within the tropics, with poleward temperature decrease concentrated in the mid latitudes. The inverse temperature gradients are characteristic of the stratosphere. A temperature minimum reflects the tropical tropopause near 100 mb.



GrADS: COLA/IGES

2006-03-02-16:53

During the boreal summer (JJA), the zone of highest lower-troposphere temperature is located well north of the Equator and meridional temperature gradient in the NH is relatively slack



GrADS: COLA/IGES

2006-03-02-16:50

During austral summer (DJF), the maximum of the lower-troposphere temperature is around the Equator, and the meridional temperature gradient in the NH mid latitudes is very steep, while the SH extratropical cap shows meridional contrasts moderately weaker than in the austral winter

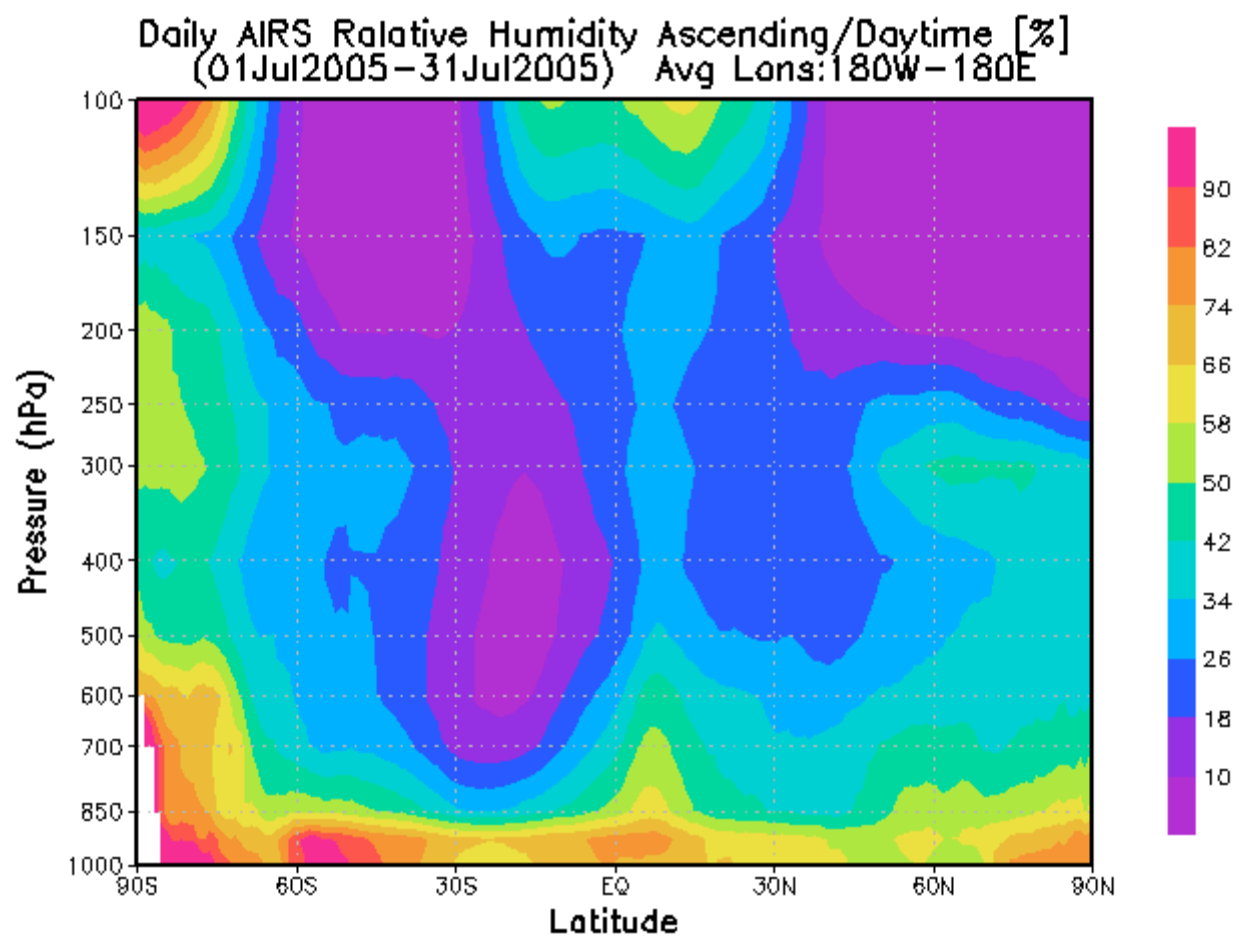
March 10, 2006

G.Leptoukh, AIRS ST'06, Pasadena



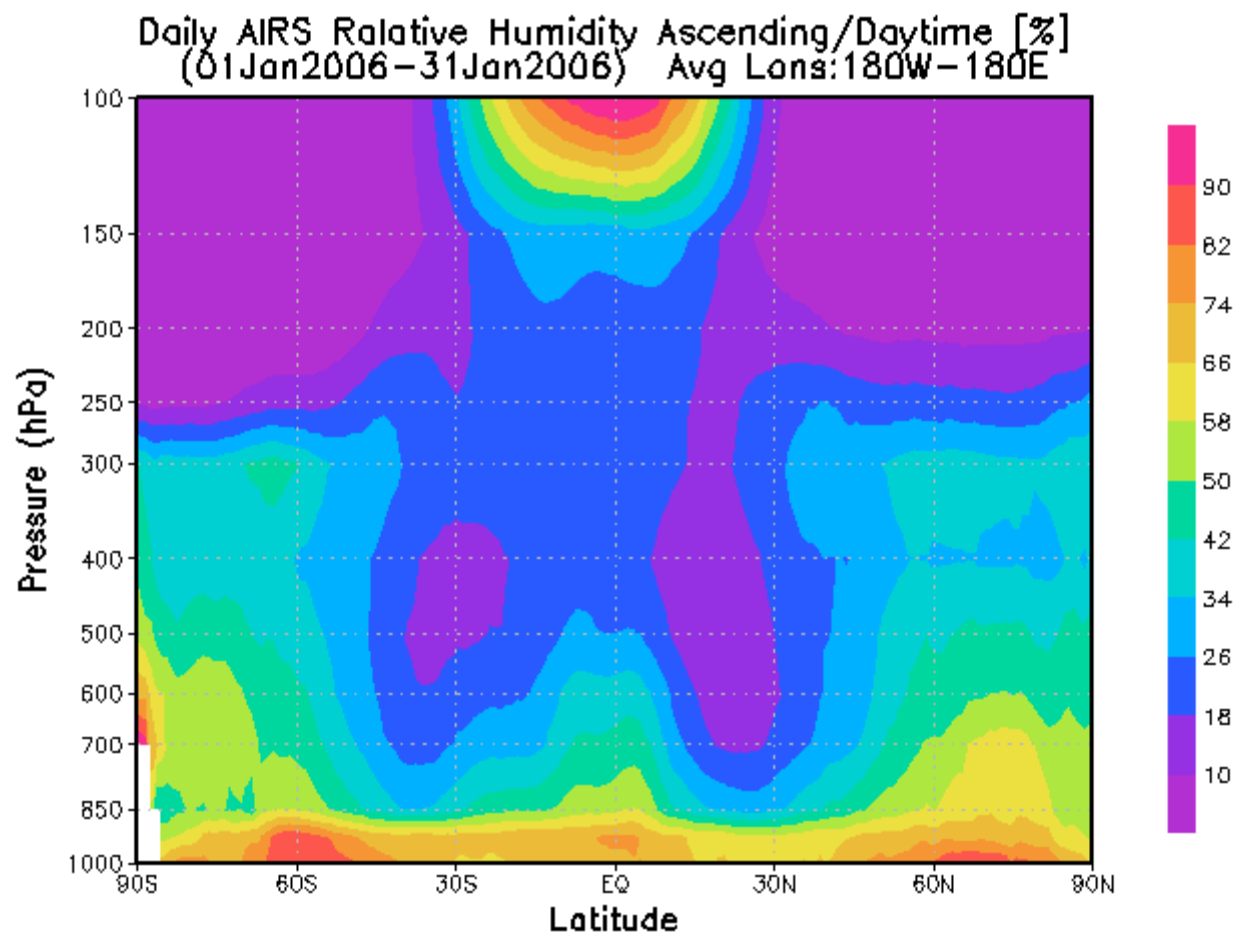
Zonal Mean of Relative Humidity Cross-section

- Relative humidity decreases with altitude. Even though the convection lifts the air to saturation, the saturated air often gets rid of excess water through precipitation process by the time it reaches cloud top – loss of most of the water content.
- Mid-tropospheric minima in the subtropics is a result of descending branch of Hadley circulation – dry descend.
- **Caveat: the numbers may not be reliable above 300 mb.**



GrADS: COLA/IGES

2006-03-02-18:59



GrADS: CDLA/IGES

2006-03-02-17:02

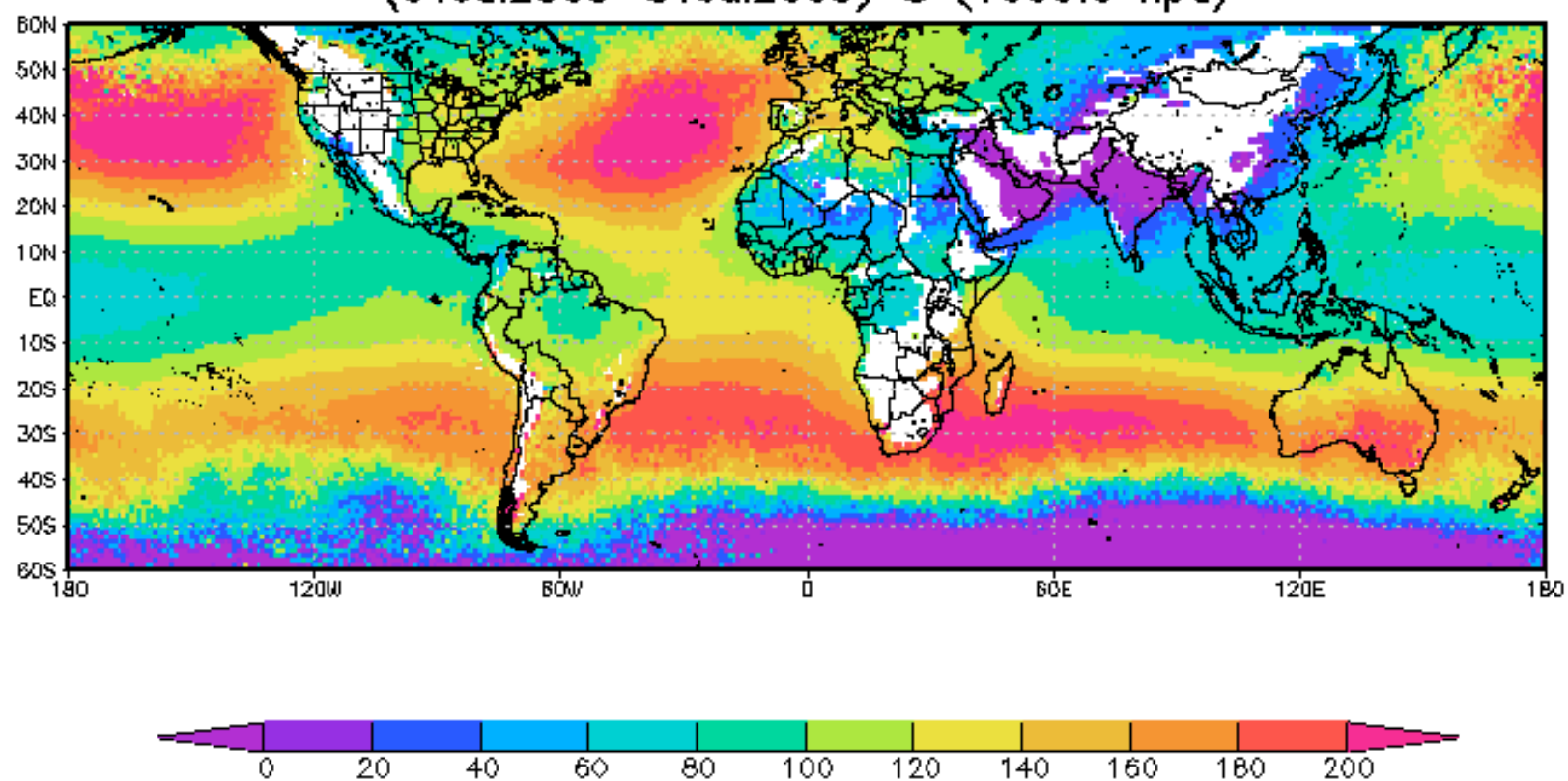


Equatorial Trough Zone

- Sandwiched between the subtropical high pressure belts of the two hemispheres, there exists a zone of low pressure extends continuously around the global near the Equator – the Equatorial Trough Zone, also known as the Intertropical Convergence Zone (ITCZ). This trough zone constitutes the ascending branches of the Hardley cell of both hemispheres.
- Broadly speaking, the low pressure trough zone coincides with a band of highest surface temperature indicating a thermally induced phenomenon (so called “heat low”).
- The location of the ITCZ varies throughout the year and while it remains near the equator, the ITCZ over land ventures farther north or south than the ITCZ over the oceans due to the variation in land temperatures. AIRS data confirms this too, which is a good thing ☺



Daily AIRS Geopotential Height Ascending/Daytime [m]
(01Jul2005–31Jul2005) @ (1000.0 hpa)

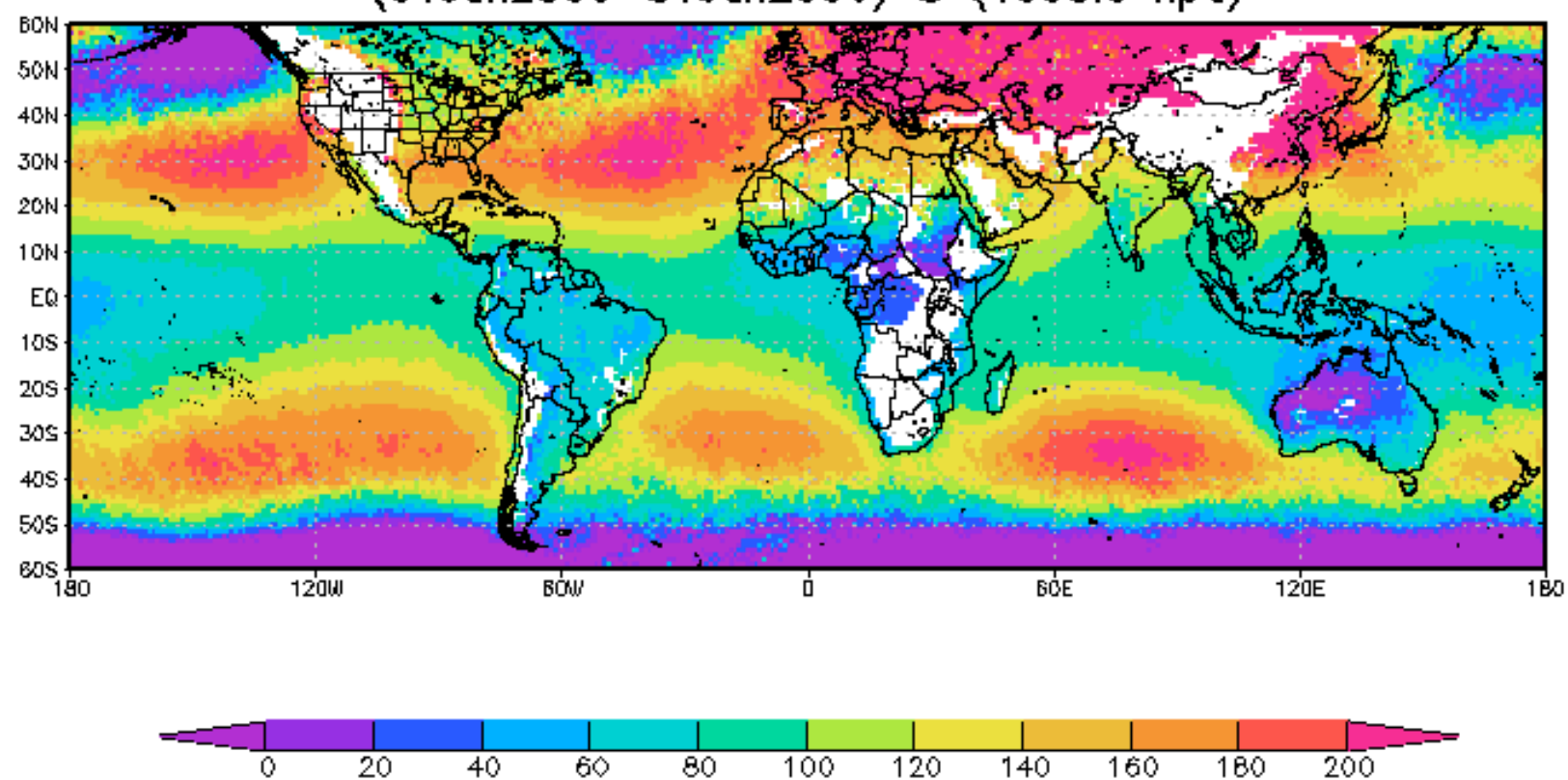


GrADS: COLA/IGES

2006-03-03-11:17

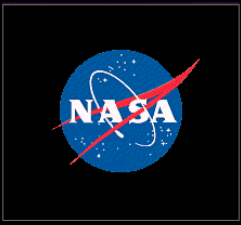


Daily AIRS Geopotential Height Ascending/Daytime [m]
(01Jan2006-31Jan2006) @ (1000.0 hpa)



GrADS: COLA/IGES

2006-03-03-11:18



Ozone Hole

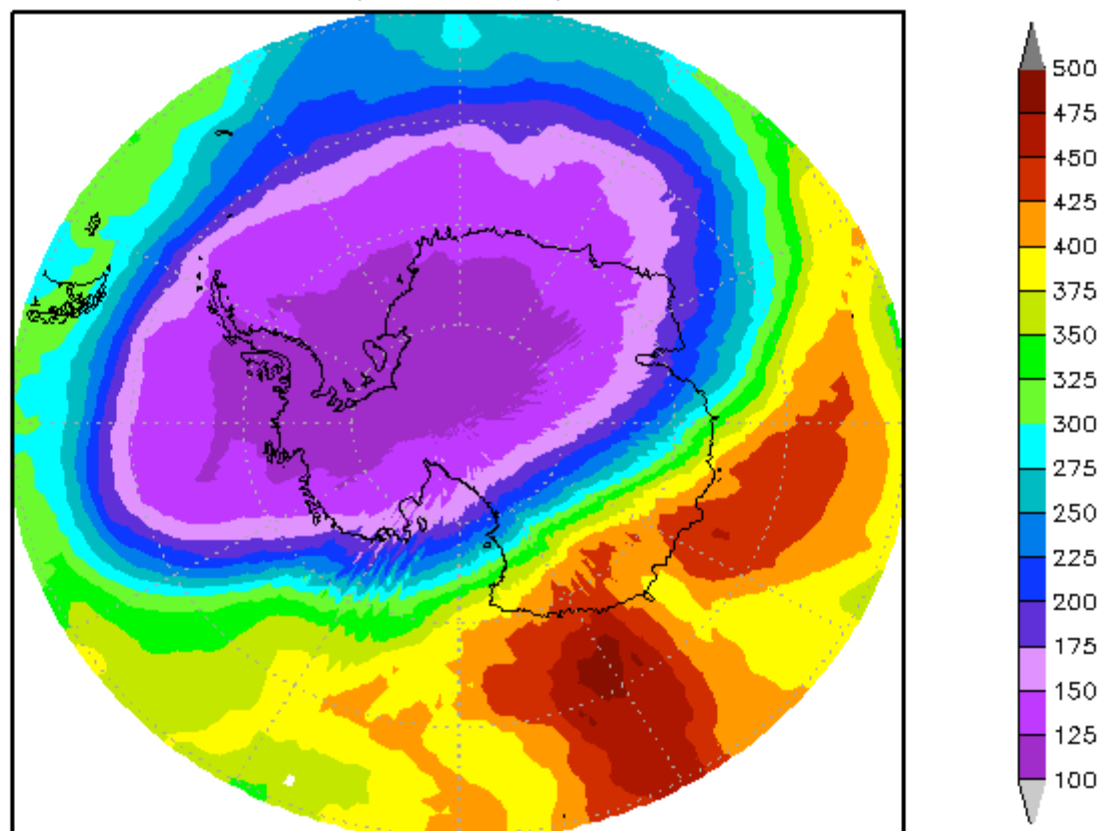
Examples of Ozone and other gases measurements by OMI, MLS, and AIRS for October 6 – 13 time period:

- Area maps of ozone
- Profiles at 65 South, 66 West (Antarctic Peninsula)

This point is below ozone minimum on October, and 7 days later Oct 13 the point is outside the ozone hole.



Column Amount Ozone [DU]
(06Oct2005)

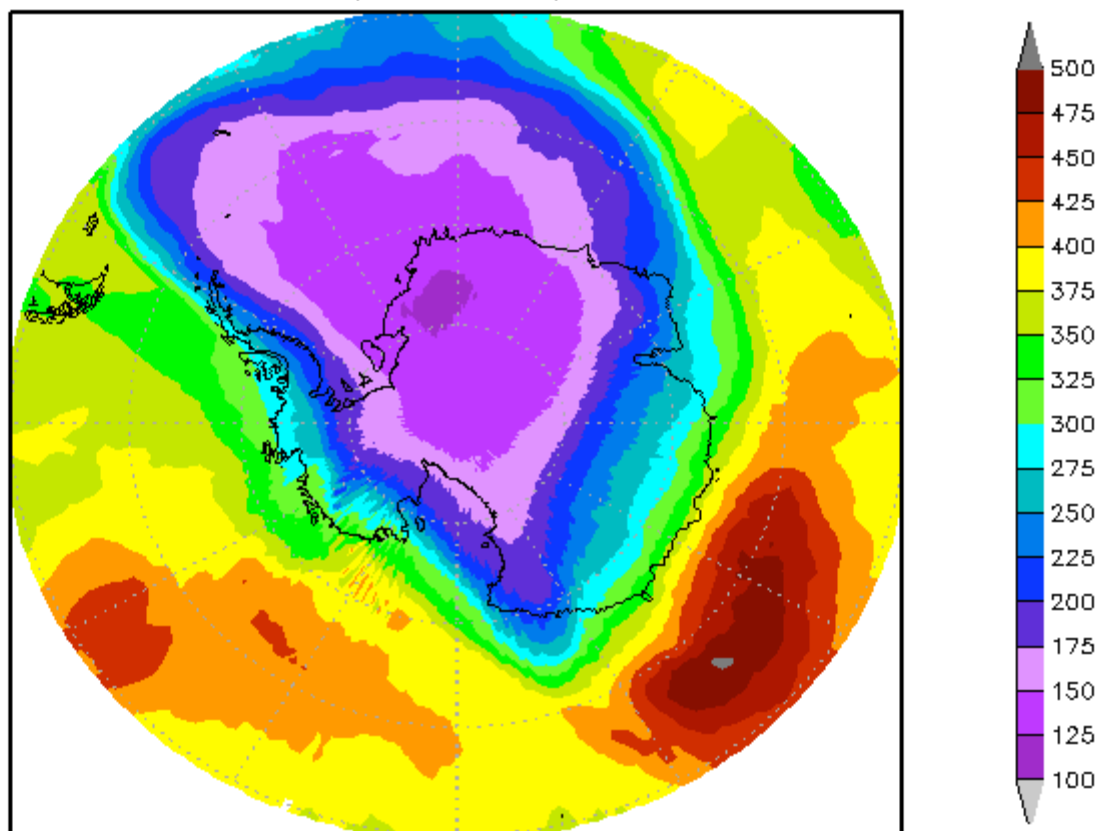


GrADS: COLA/IGES

2006-03-04-15:18



Column Amount Ozone [DU]
(13Oct2005)

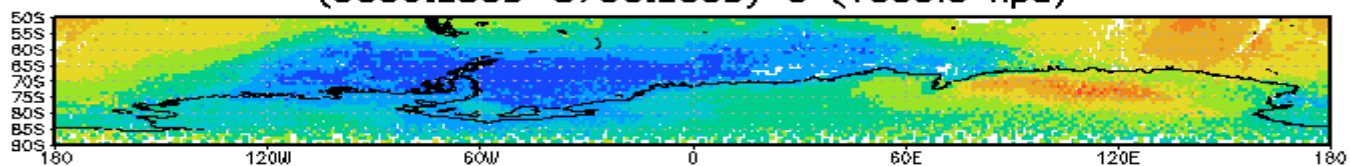


GrADS: COLA/IGES

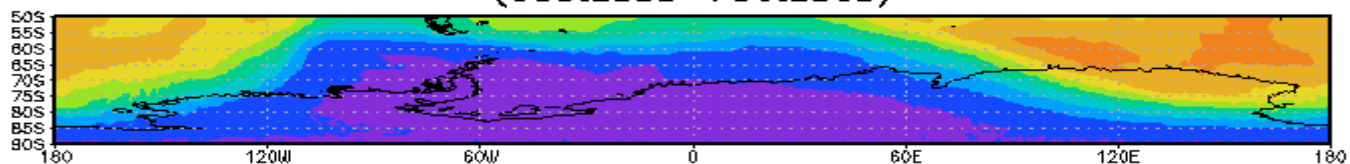
2006-03-04-15:18



Daily AIRS I3 Column Amount Ozone Descending/Nighttime [DU]
(06Oct2005-07Oct2005) @ (1000.0 hpa)

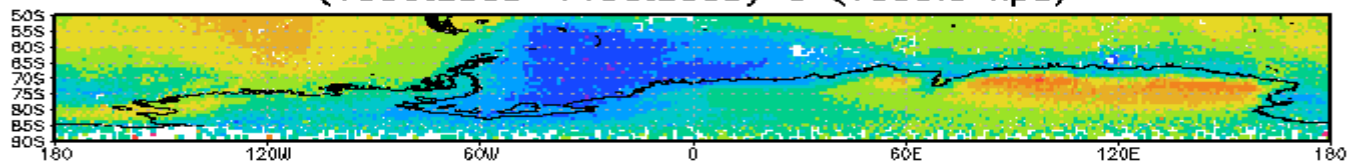


Column Amount Ozone [DU]
(6Oct2005-7Oct2005)

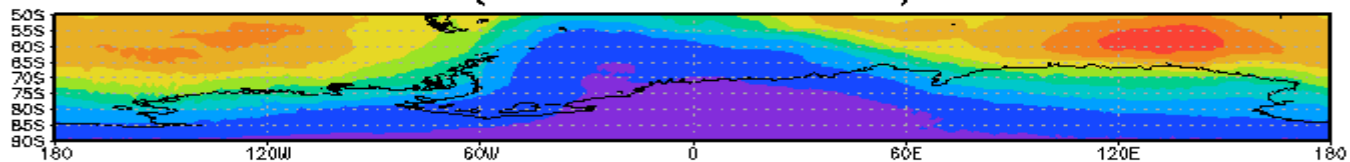




Daily AIRSI3 Column Amount Ozone Descending/Nighttime [DU]
(13Oct2005-14Oct2005) @ (1000.0 hpa)



Column Amount Ozone [DU]
(13Oct2005-14Oct2005)

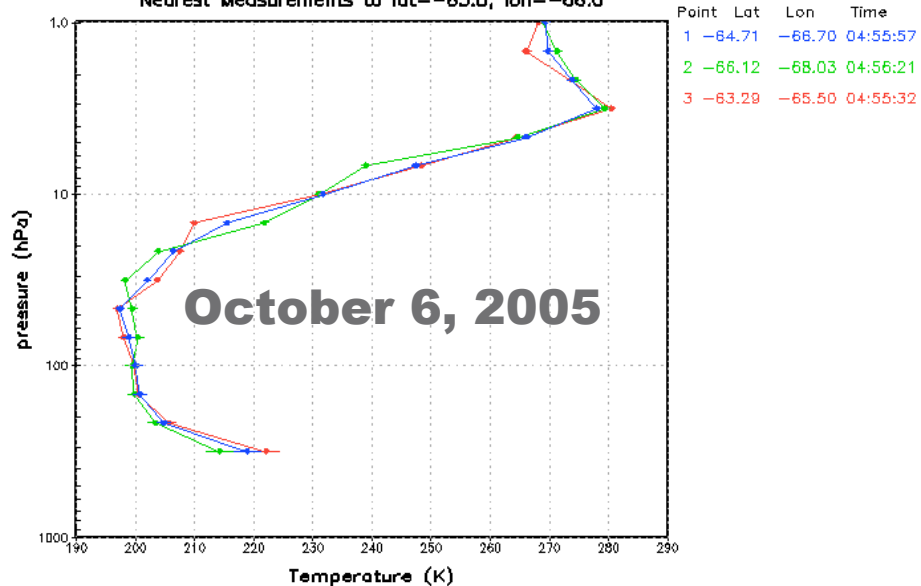


Temperature

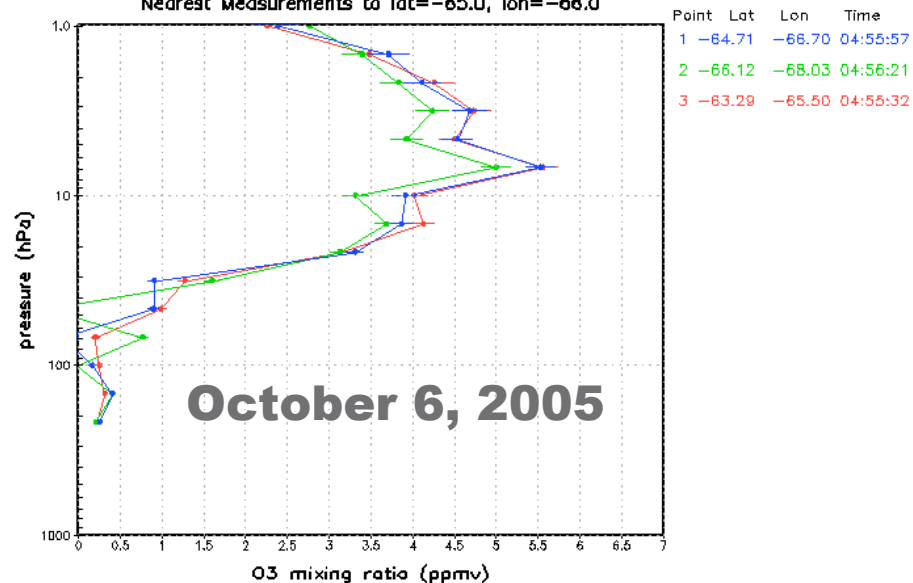
MLS

Ozone

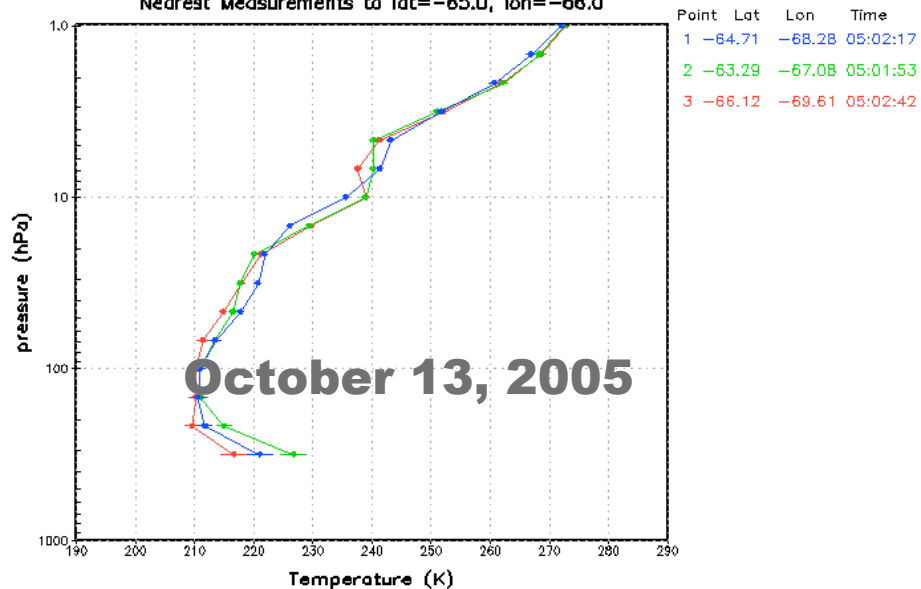
MLS Temperature Profile for Oct 06, 2005
Nearest Measurements to lat=-65.0, lon=-66.0



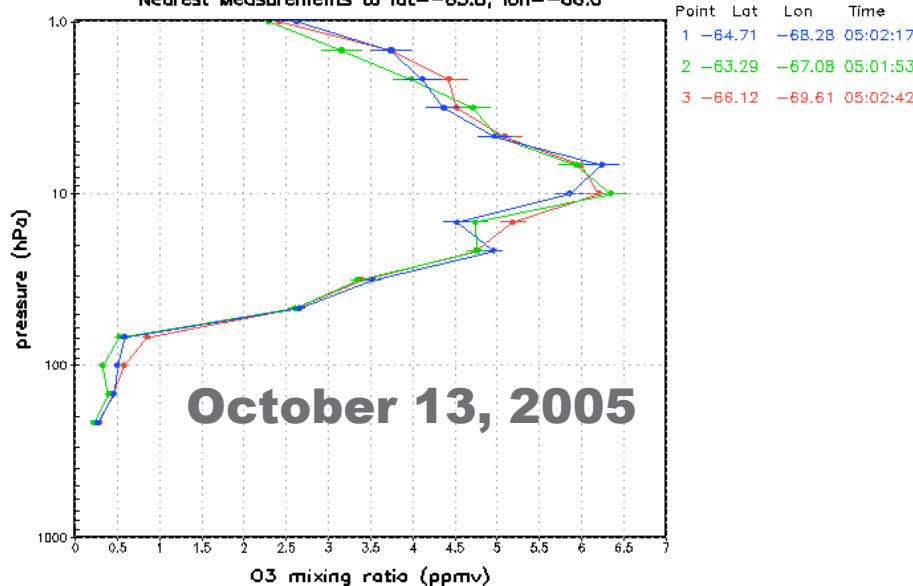
MLS O3 Profile for Oct 06, 2005
Nearest Measurements to lat=-65.0, lon=-66.0



MLS Temperature Profile for Oct 13, 2005
Nearest Measurements to lat=-65.0, lon=-66.0

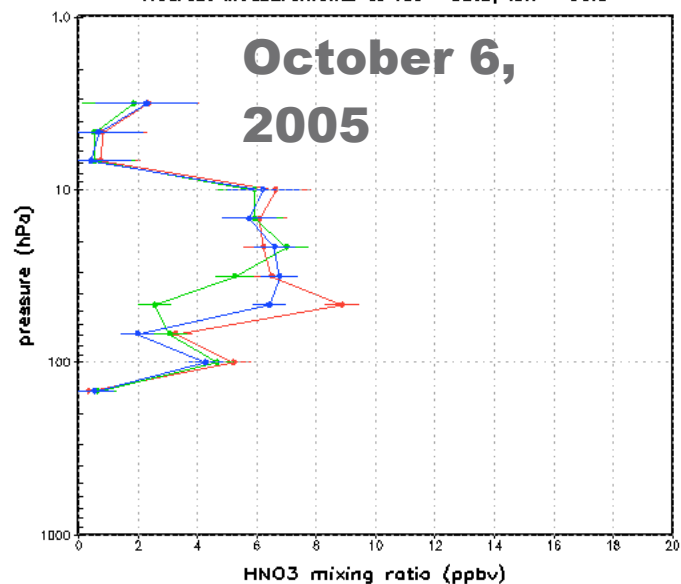


MLS O3 Profile for Oct 13, 2005
Nearest Measurements to lat=-65.0, lon=-66.0



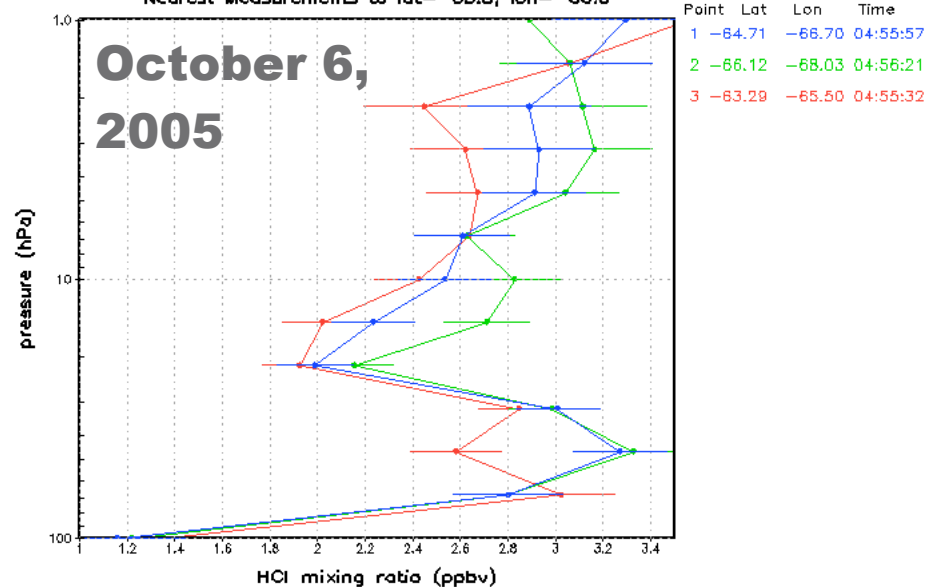
Nitric Acid

MLS HN03 Profile for Oct 06, 2005
Nearest Measurements to lat=-85.0, lon=-66.0

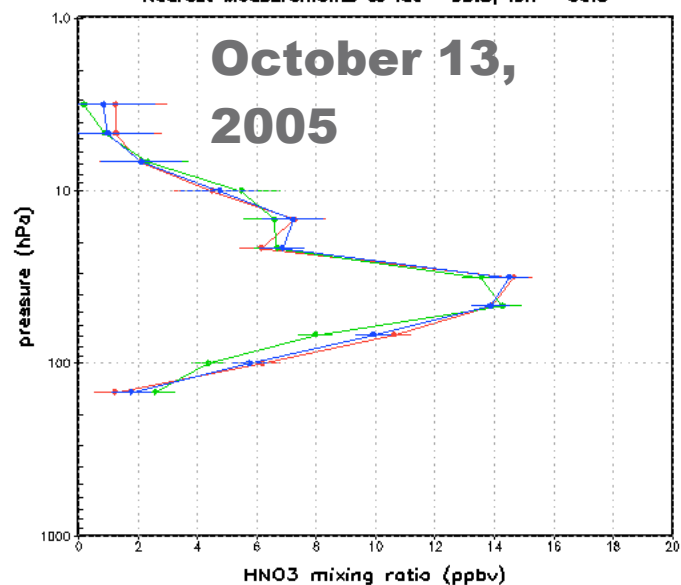


Hydrogen Chloride

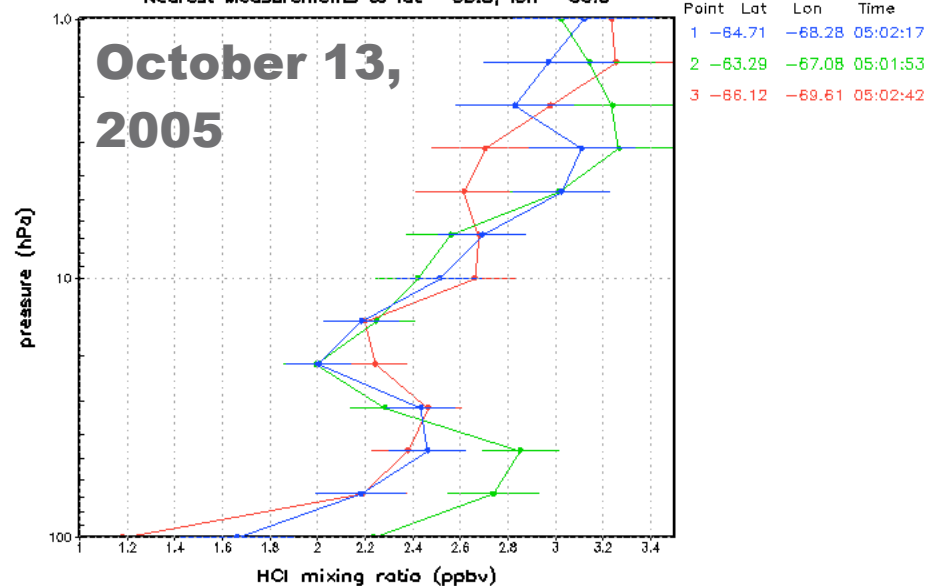
MLS HCl Profile for Oct 06, 2005
Nearest Measurements to lat=-85.0, lon=-66.0



MLS HN03 Profile for Oct 13, 2005
Nearest Measurements to lat=-85.0, lon=-66.0



MLS HCl Profile for Oct 13, 2005
Nearest Measurements to lat=-85.0, lon=-66.0





Saharan Dust transport

Examples of Aerosol Optical Depth, UV
Aerosol Index, Precipitation for 2000 –
2005, and then for Aug 2005.

Measurements by OMI, MODIS, and TRMM

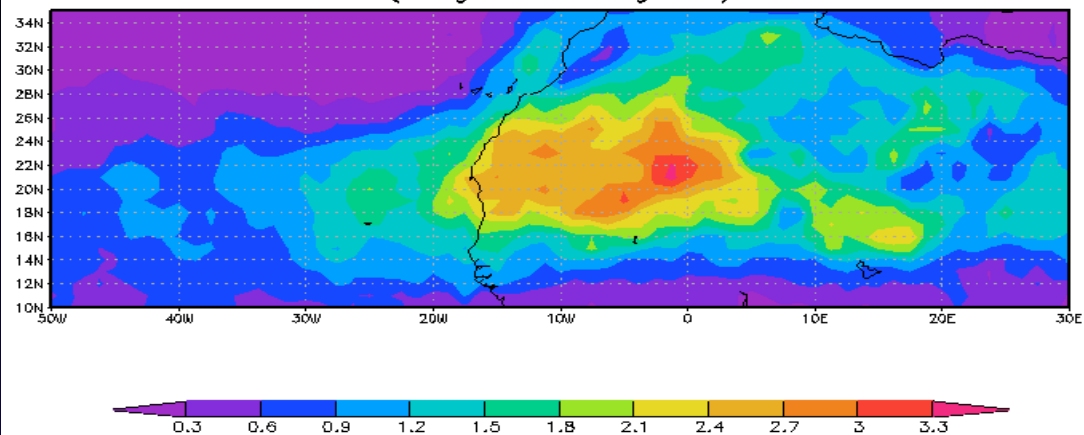
- Area maps of
- Lon-time Hovmoller plot

Dust in August 2005 propagated westward.



OMI

UV Aerosol Index [unitless]
(1Aug2005–31Aug2005)

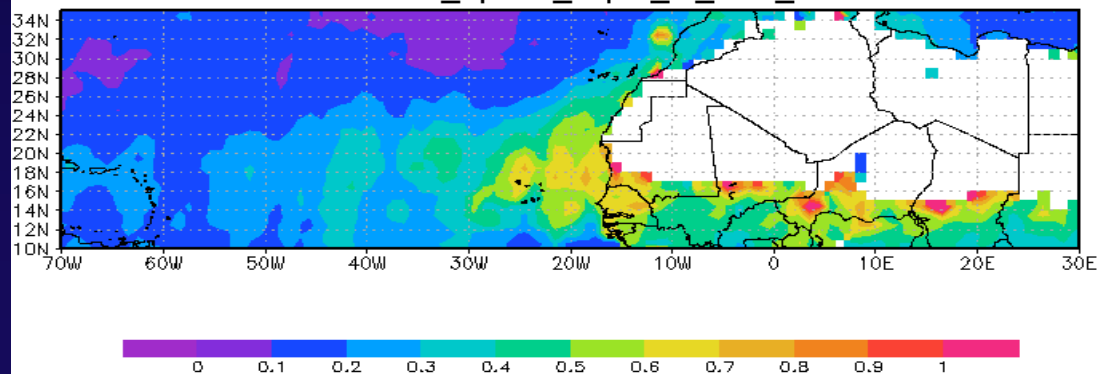


GrADS: GDIA/IGES

2006-03-04-18:20

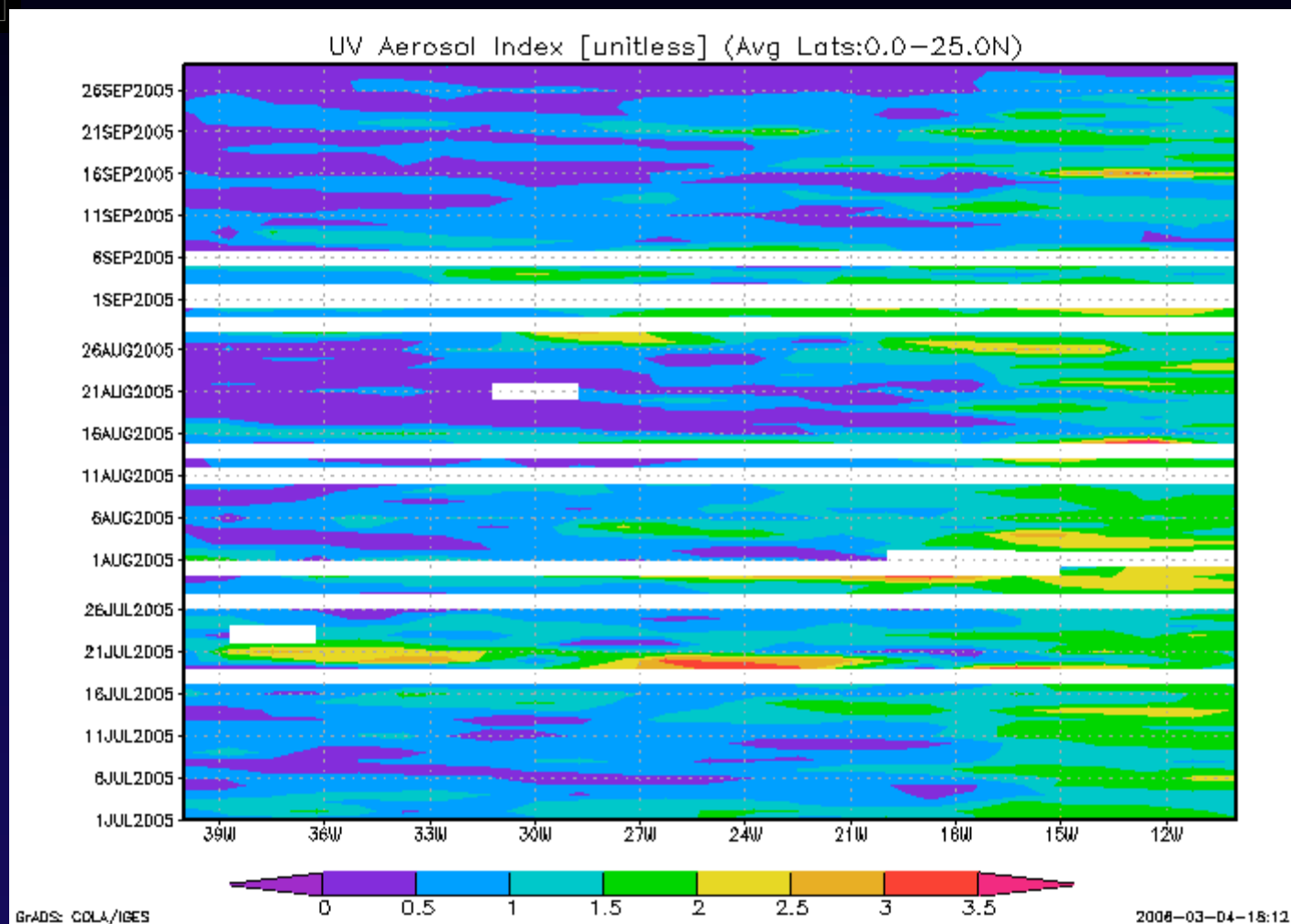
MODIS-Terra

[unitless] (Aug2005)
Terra Aerosol_Optical_Depth_at_0.55_Micron



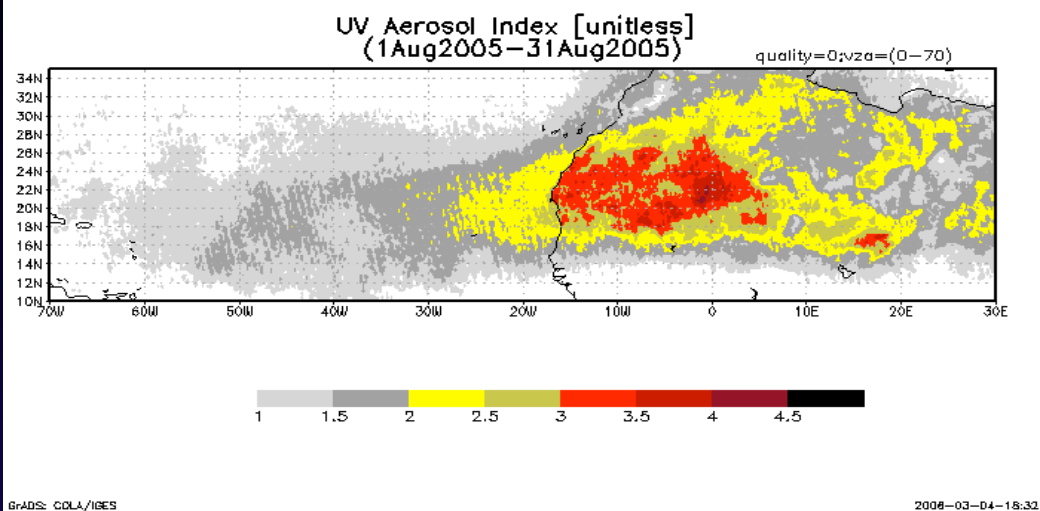
GrADS: GDIA/IGES

2006-03-04-18:22

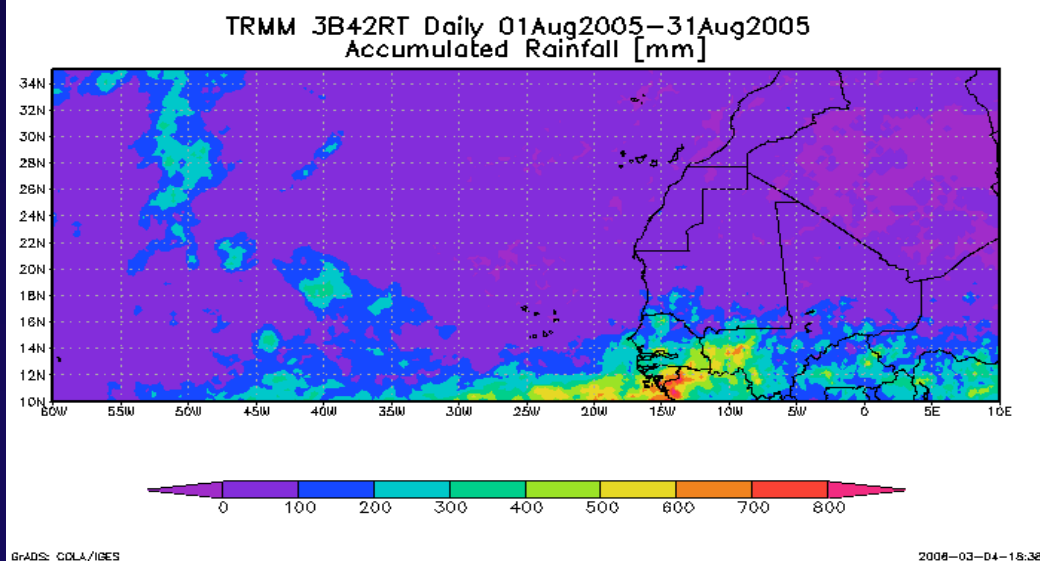




OMI

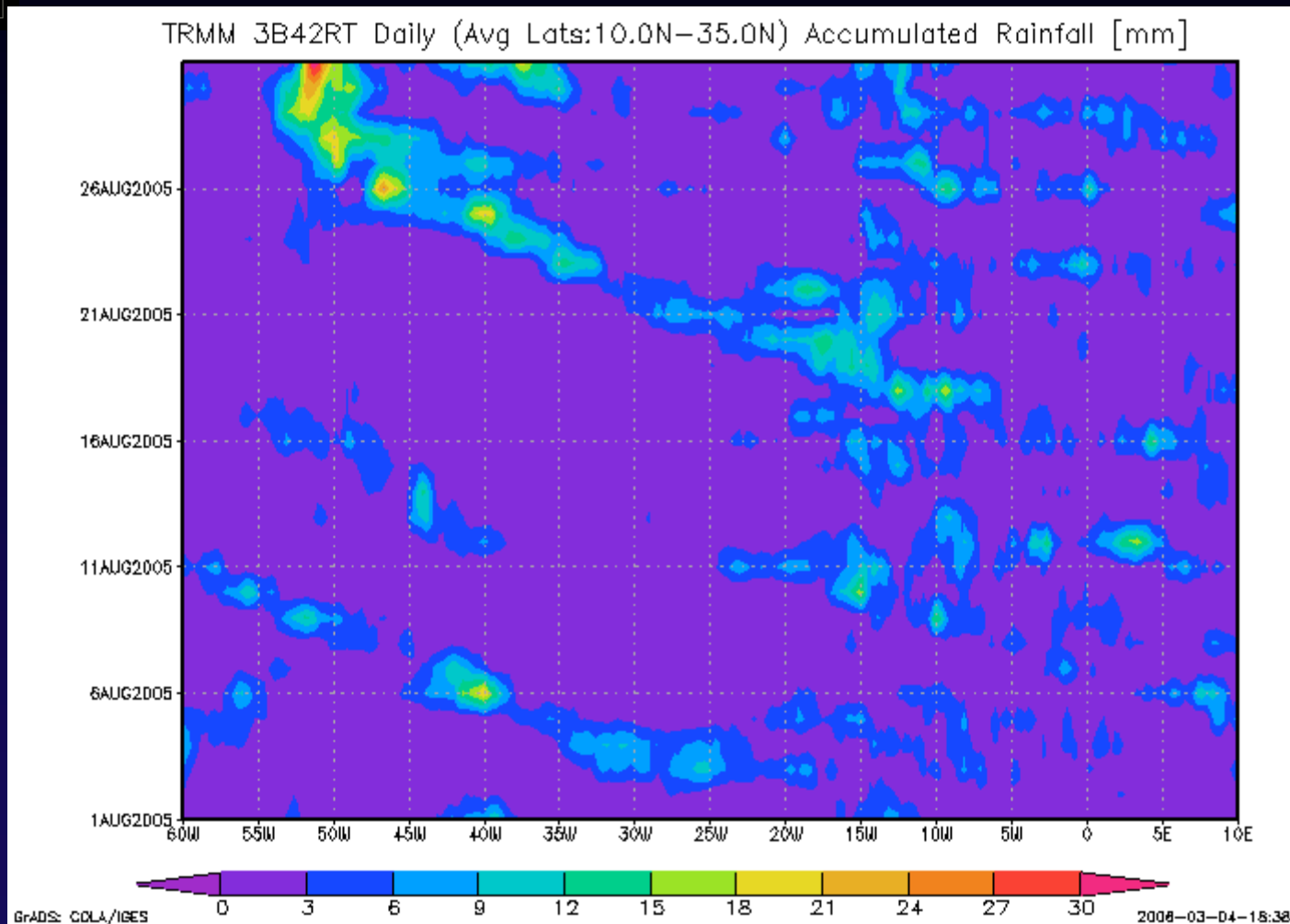


TRMM precipitation





TRMM Accumulated Rainfall



Hovmoller plot show rain propagation westward



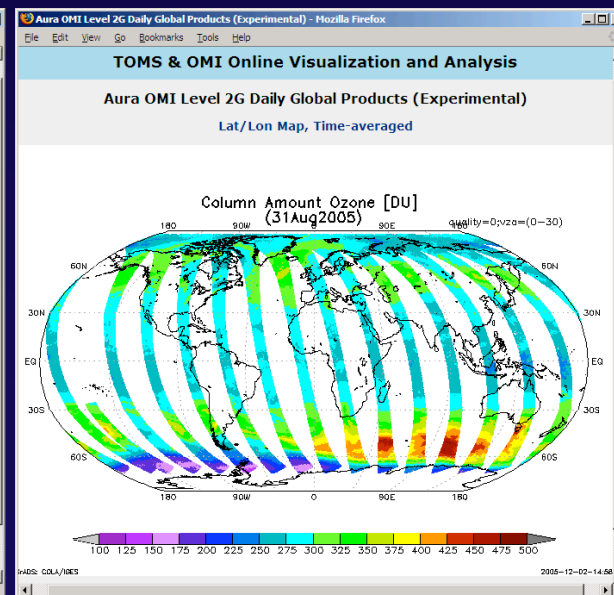
Between Level 2 and 3

- OMI L2G is an example of saving most of the L2 information to allow users generate gridded maps ("on-the-fly" Level 3) based on user-specific mapping, filtering and averaging methods
- To compare Level 3 from various instruments in Giovanni, L2G-like products are vital
- For AIRS, to compare with MODIS and other instruments, L2G-like product is needed



Giovanni is able to create virtual OMI gridded global/regional products on-line from L2G data with filtering/selection options:

- In addition to selecting parameters, area, and time period, users will be able to filter results based on the algorithm quality flags, viewing and solar zenith angles ranges, surface reflectivity ranges, aerosol index values, etc.
- Users will also have the option to obtain for a grid value with either the best pixel or a simple average of the data points, or the area weighted average
- The ASCII output for a selected region will contain grid average values as well as the original values (including lat and long, viewing and solar zenith angles or path length, surface reflectivity or aerosol index) of the pixels that are used in averaging over a grid cell





Multi-sensor intercomparison



Giovanni family now

- **MOVAS** - intercomparison analyses between aerosol-related parameters of **MODIS** (Terra and Aqua) and the Goddard Chemistry Aerosol Radiation and Transport (**GOCART**) model.
- **TOVAS** (operational since March 2001) is the **TRMM** Online Visualization and Analysis System, based primarily on data from the Tropical Rainfall Measuring Mission
- **Ocean Color Giovanni** - access to **SeaWiFS** and **MODIS** Aqua global monthly chlorophyll and other ocean data from the start of missions. Supports the Ocean-Color Time-Series funded by the NASA
- **Ozone Giovanni** (Atmospheric Composition family) - vis & analysis of **EP** and **Nimbus-7 TOMS**, and **Aura OMI** (TOMS-like) Daily Global Products
- **AIRS Giovanni** - vertical profiles of temperature, humidity and geopotential height from **AIRS** daily global product
- **MLS Giovanni** - vertical profiles of trace gases from **Aura MLS** daily global product
- **UARS/HALOE Giovanni** – convenient access to atmospheric profiles of trace gases

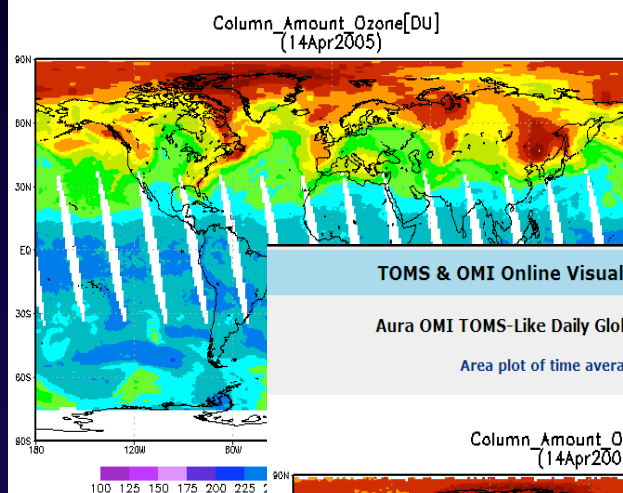


Multi-sensor ozone measurements

TOMS & OMI Online Visualization and Analysis

Earth Probe TOMS Daily Global $1.0^\circ \times 1.25^\circ$ Products

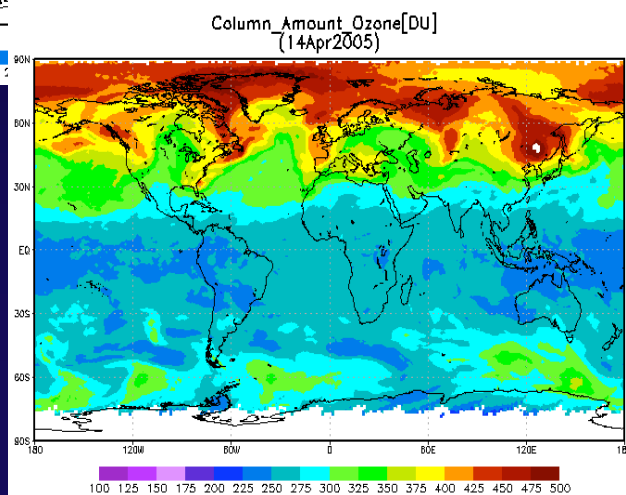
Area plot of time averaged parameter



TOMS & OMI Online Visualization and Analysis

Aura OMI TOMS-Like Daily Global $1.0^\circ \times 1.25^\circ$ Products

Area plot of time averaged parameter

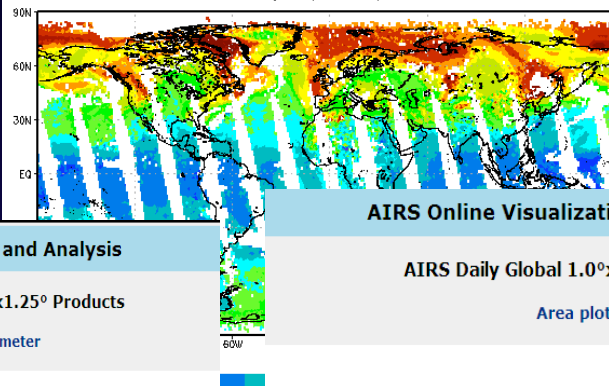


AIRS Online Visualization and Analysis

AIRS Daily Global $1.0^\circ \times 1.0^\circ$ Products

Area plot

Column Amount Ozone Ascending/Daytime [DU]
(14Apr2005)

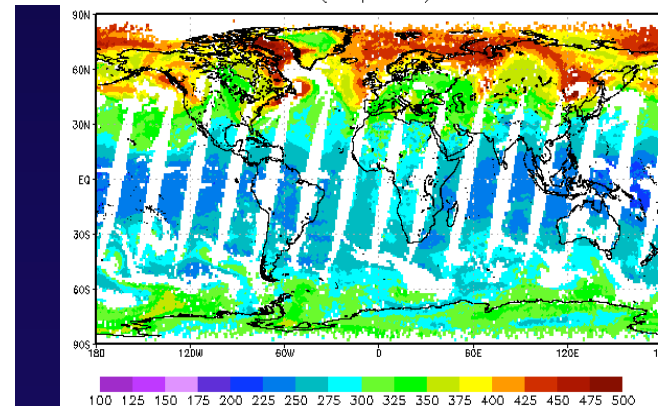


AIRS Online Visualization and Analysis

AIRS Daily Global $1.0^\circ \times 1.0^\circ$ Products

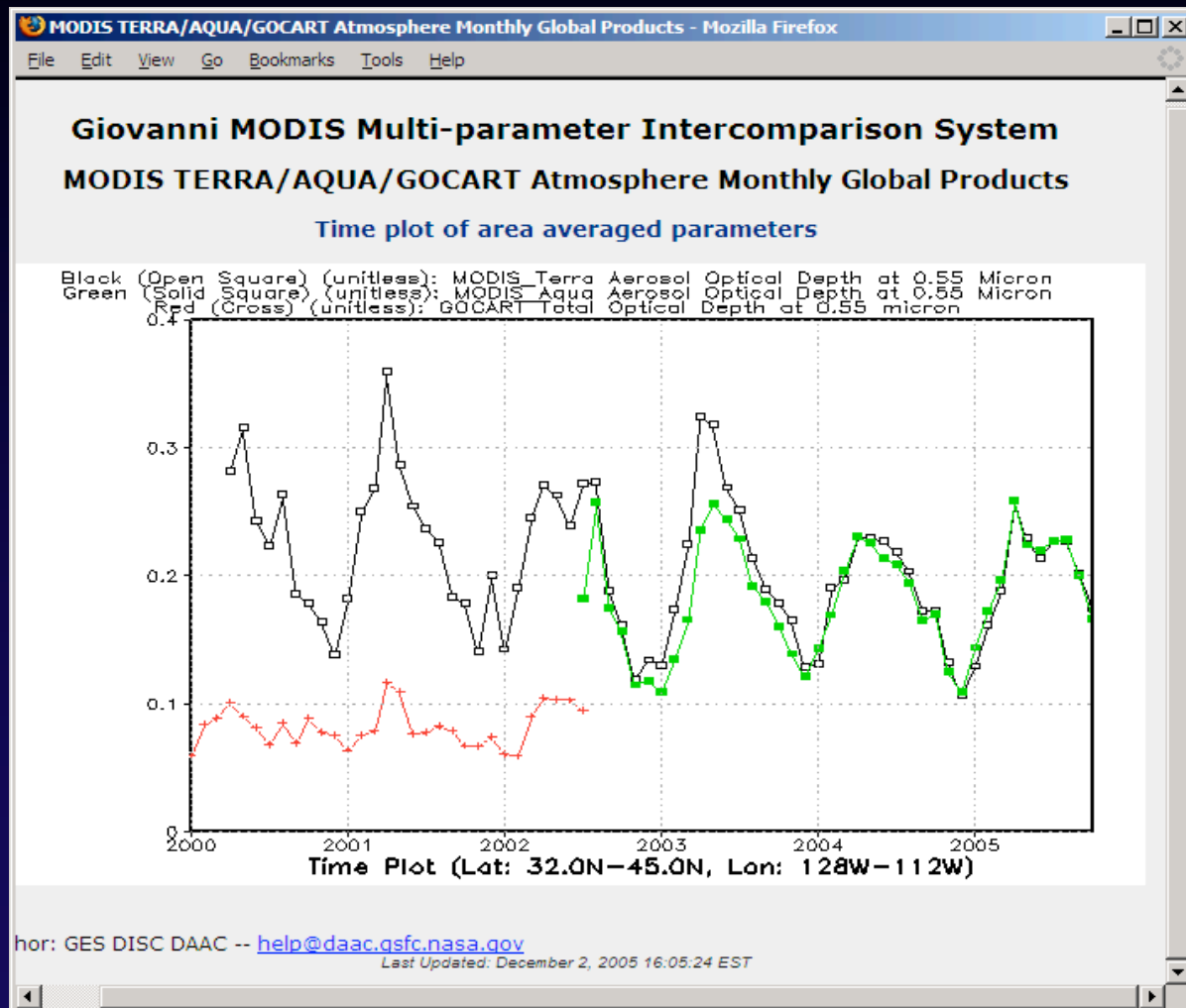
Area plot

Column Amount Ozone Descending/Nighttime [DU]
(14Apr2005)

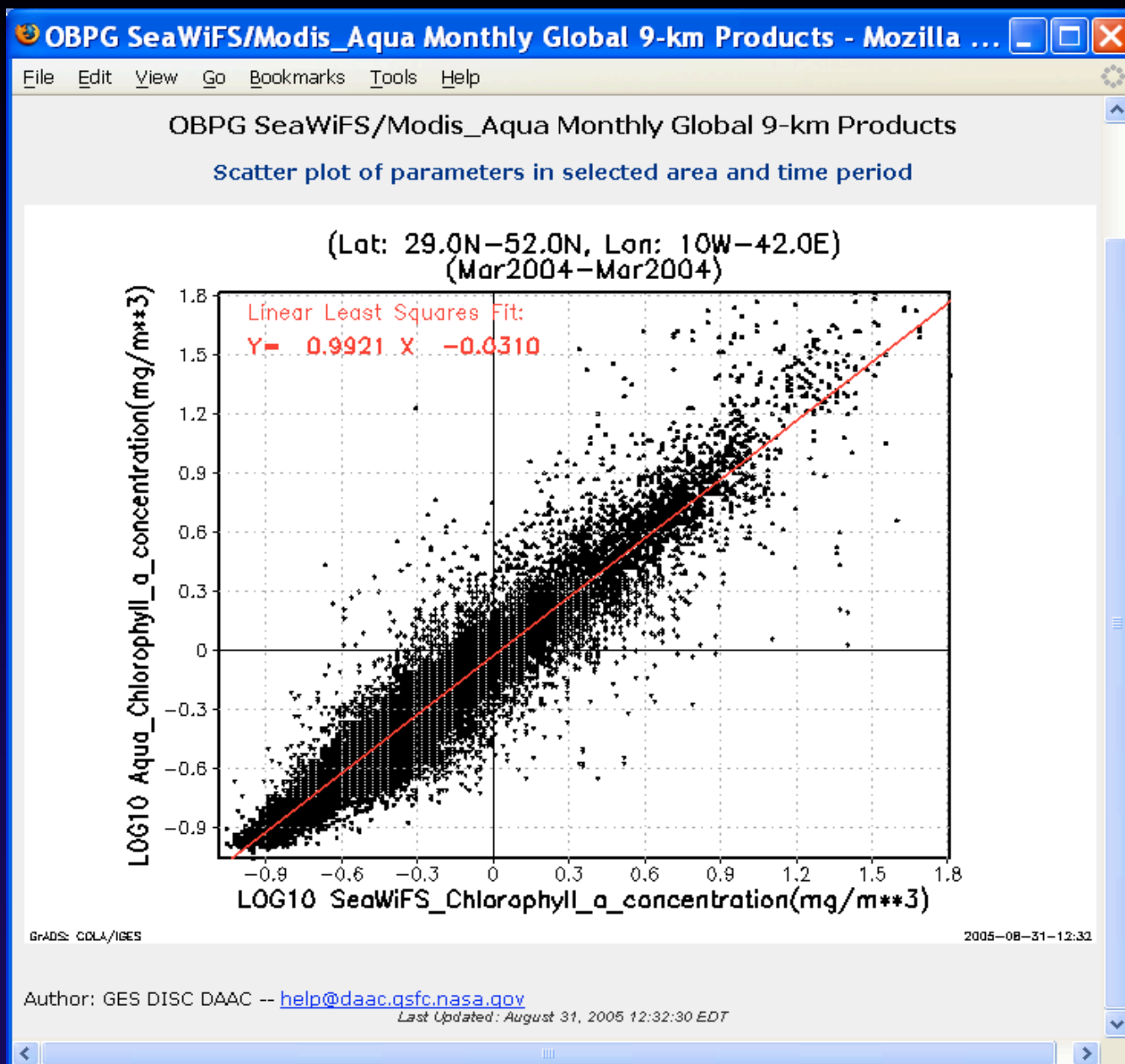


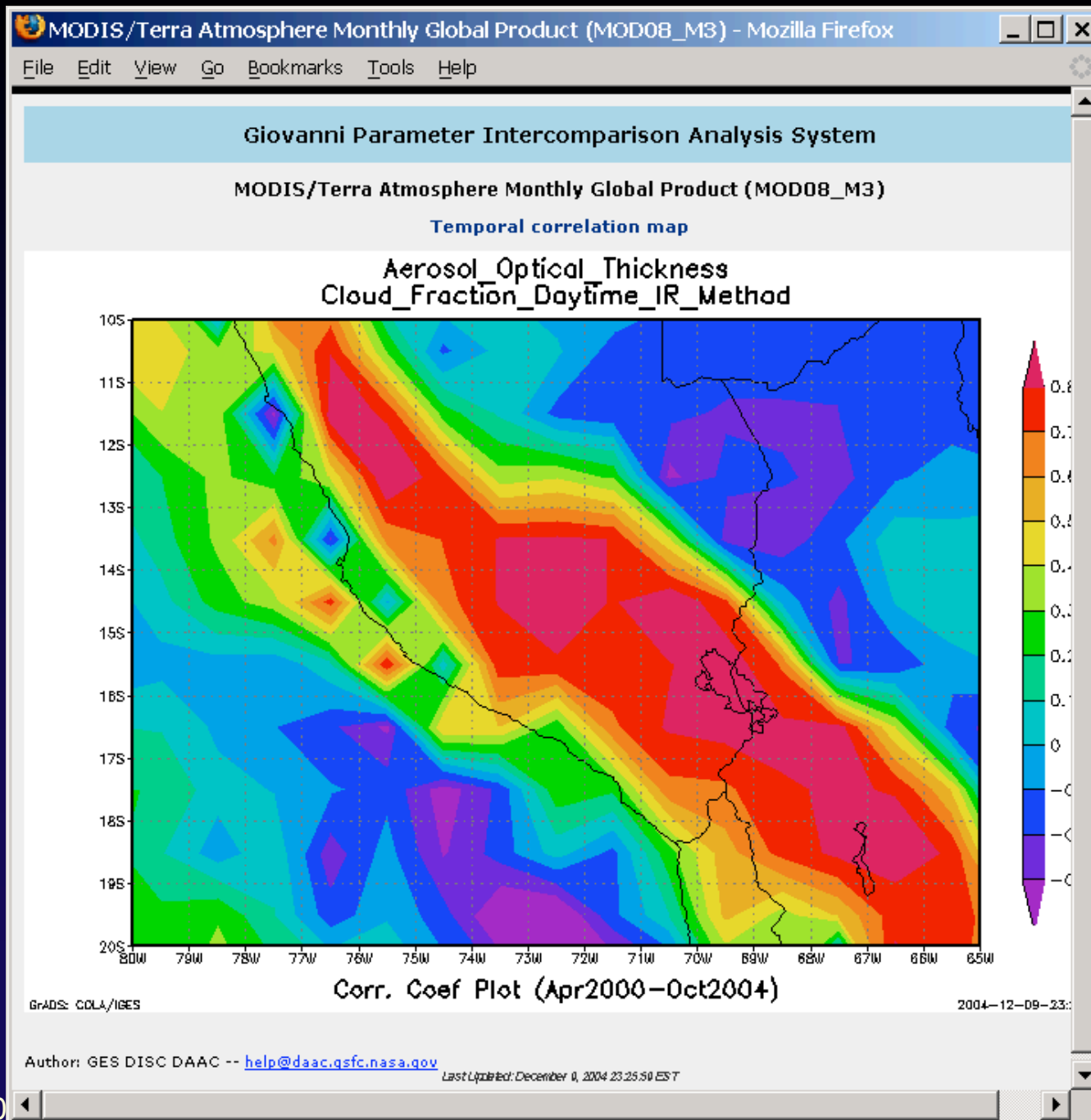


Multi-parameter intercomparison



Time-series of AOD from MODIS Terra, MODIS Aqua and GOCART







Giovanni capabilities

Basic (one-parameter):

- **Area plot** – averaged or accumulated over any available data period for any rectangular area
- **Time plot** – time series averaged over any rectangular area
- **Hovmoller plots** – longitude-time or latitude-time cross sections
- **ASCII output** – for all plot types (can be used with GIS apps)
- **Image animation** – for area plot

Beyond basics:

- **Area plot** - geographical intercomparison between two parameters.
- **Time plot** - an X-Y time series plot of several parameters.
- **Scatter plot of parameters in selected area and time period** - relationship between two parameters geographically.
- **Scatter plot of area averaged parameters** - regional (i.e., spatially averaged) relationship between two parameters.
- **Temporal correlation map** - relationship between two parameters at each grid point in the selected spatial area.
- **Temporal correlation of area averaged parameters** - a single value of the correlation coefficient of a pair of selected parameters.



Statistics



Giovanni Averaging Function 1

Interval- Weighted Averaging (GrADS Function Name: **ave**)

This averaging is weighted by grid interval to account for the uneven grid spacing. **Missing data** values do not participate - the average is taken with fewer data points. The average in the latitude dimension is weighted by the difference between the sines of the latitude at the northern and southern edges of the grid box. The edges of the grid box are always defined as being the mid point between adjacent grid points.

For grid box “j”:

$$X_{ave} = \frac{\sum_{i=1}^n X_i w_i}{\sum_{i=1}^n w_i}$$

For Averaging in Time

$$w_i = (t_{i+1} - t_i)$$

For Averaging in Longitude

$$w_i = [Lon_i^{east} - Lon_i^{west}]$$

For Averaging in Latitude

$$w_i = [Sin(Lat_i^{north}) - Sin(Lat_i^{south})]$$



Giovanni Averaging Function 2

Area- Weighted Averaging (GrADS Function Name: *aave*)

This function takes an areal average over a user-selected latitude-longitude region. This average does weighting in the latitude dimension by the difference between the sines of the latitude at the northern and southern edges of the grid box and weighting in the longitude dimension by the interval between the two adjacent grid points as well. **Missing data** values do not participate in this average.

For Grid Box “j”:

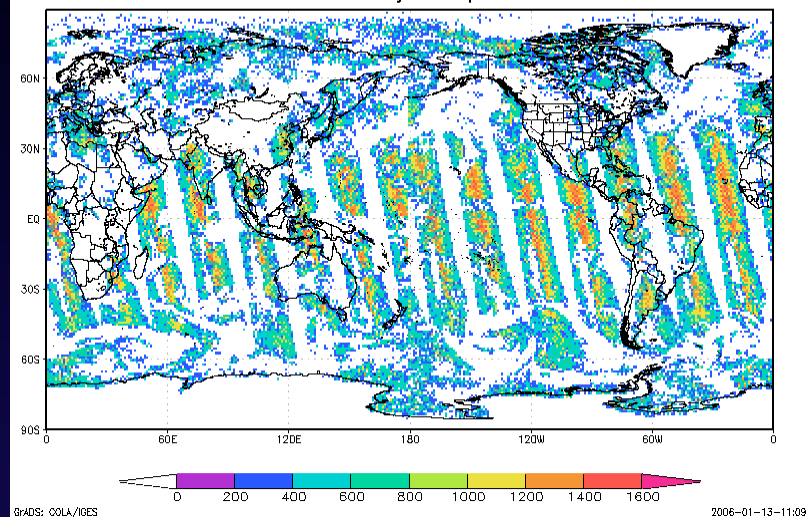
$$X_{area_ave} = \frac{\sum_{i=1}^n X_i w_i}{\sum_{i=1}^n w_i}$$

$$w_i = [Sin(Lat_i^{north}) - Sin(Lat_i^{south})] * [Lon_i^{east} - Lon_i^{west}]$$

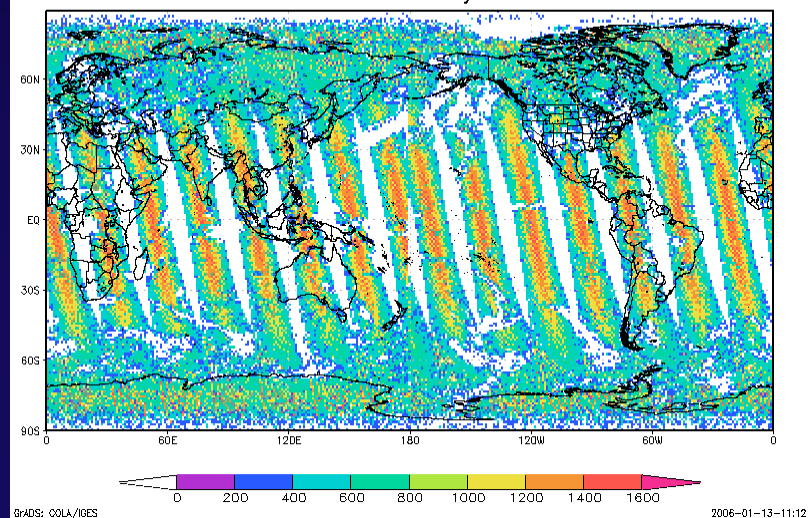


Number of Pixels for AIRS

Number of Pixels of AIRS Daily Temp at 1000mb 02Jan2005



Number of Pixels of AIRS Daily Ozone 02Jan2005

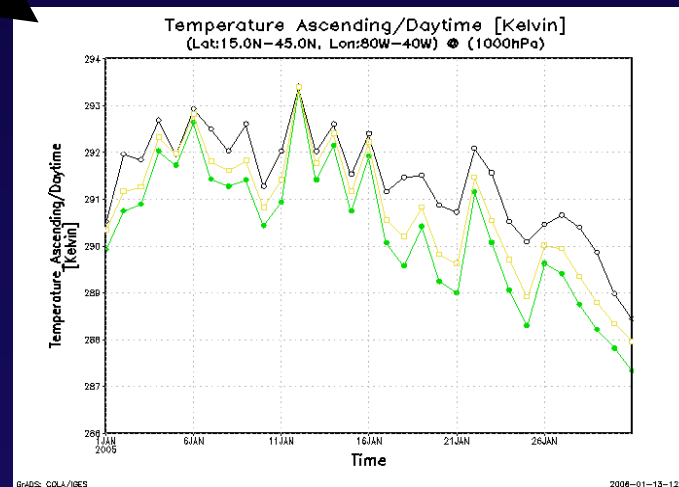
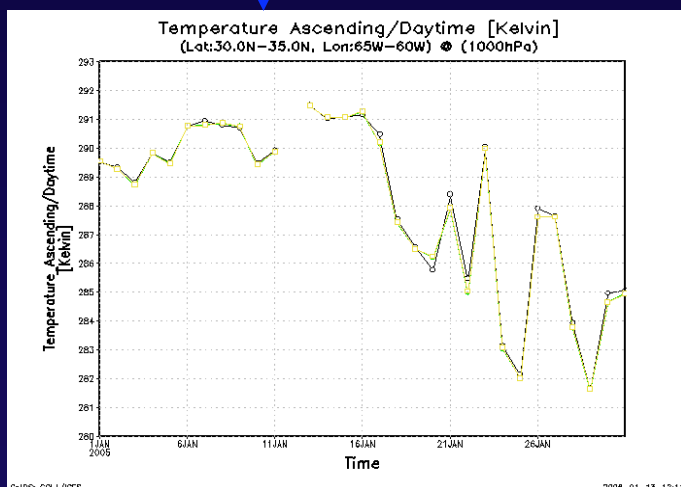
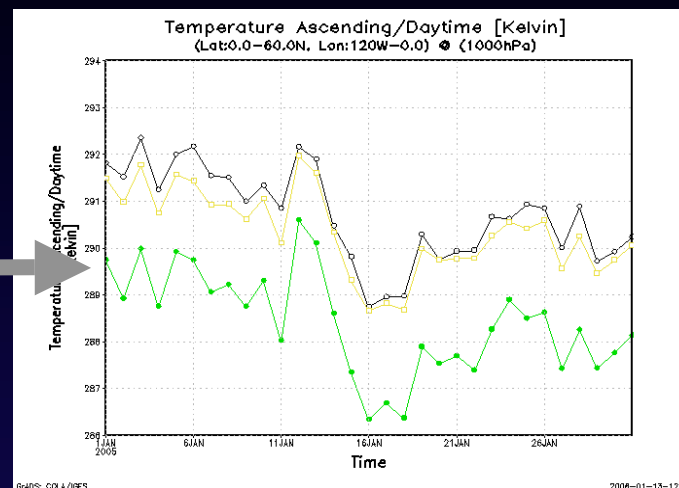
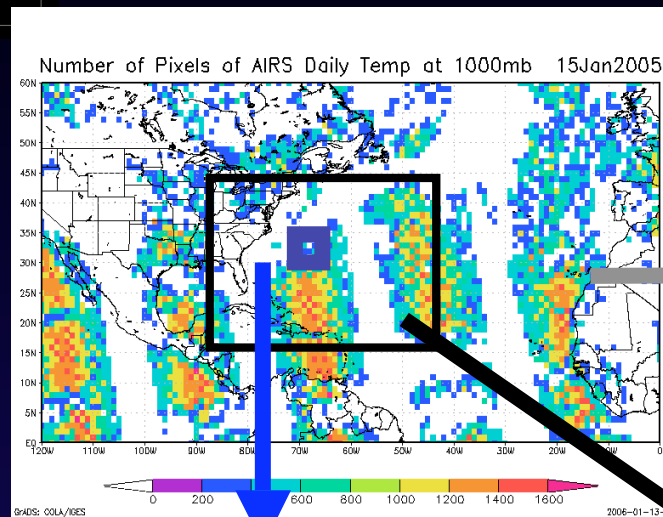


March 10, 2006

G.Leptoukh, AIRS ST06, Pasadena



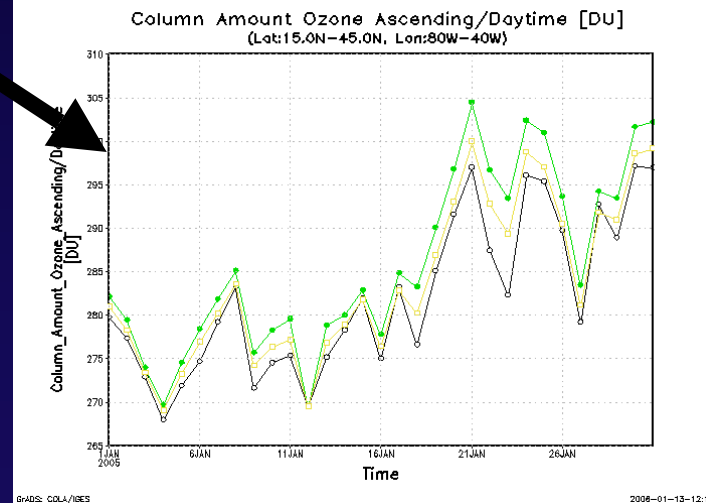
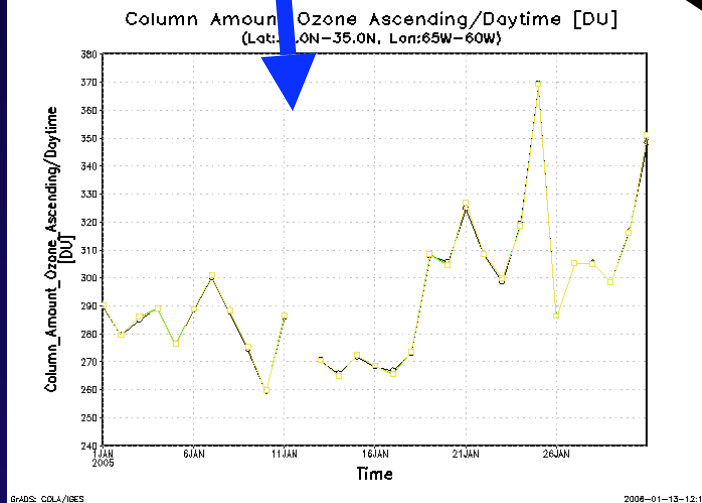
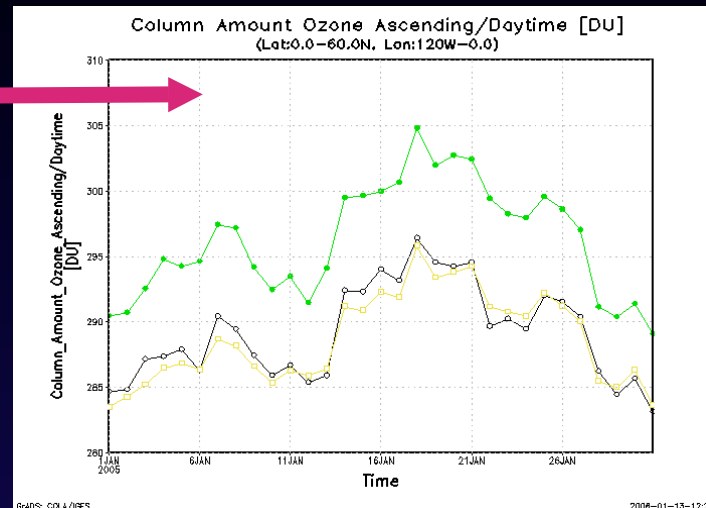
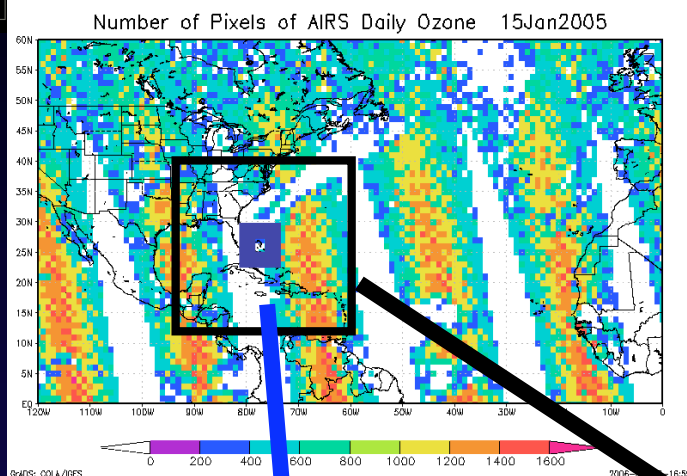
AIRS Temperature time-series



Green - no weighting, black - NP weighting, yellow area weighting



AIRS Ozone time-series



Green - no weighting, black - NP weighting, yellow area weighting



Future of AIRS in Giovanni

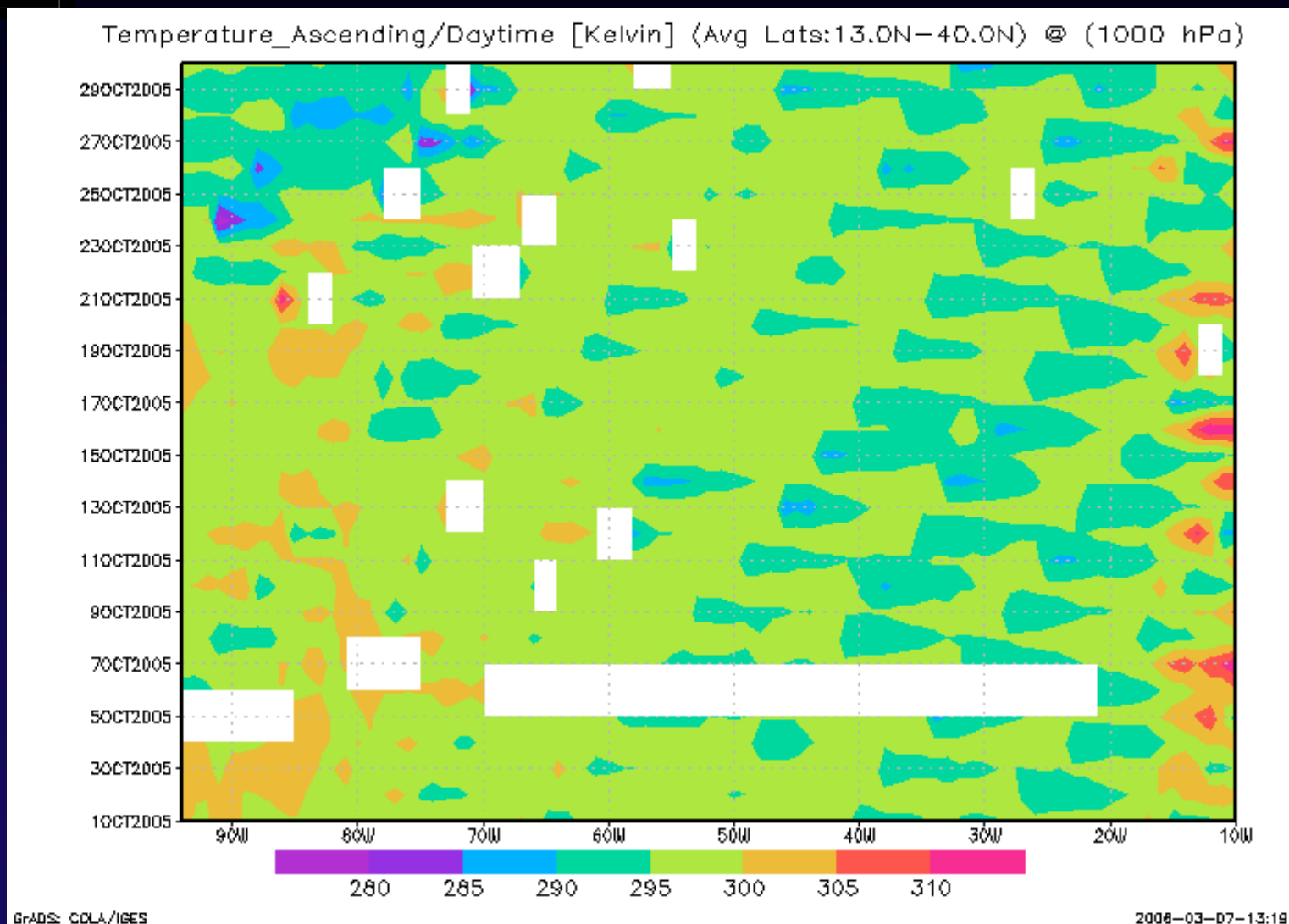
What functionalities to add to AIRS Giovanni?

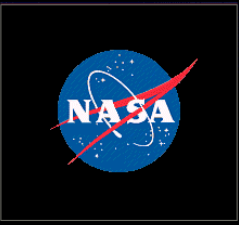
- Animation
- Handle different grid definitions, like synoptic (MODIS) and linear time (AIRS)
- Add AIRS multi-day products
- Intercomparison with MODIS
- Point profiles

Feedback requested!



Hovmoller using daily products?





A-Train Data Depot (ATDD)

ACCESS Award:

“A-Train Data Depot: Integrating Atmospheric Measurements Along the A-Train Tracks Utilizing Data from the Aqua, CloudSat and CALIPSO Missions”

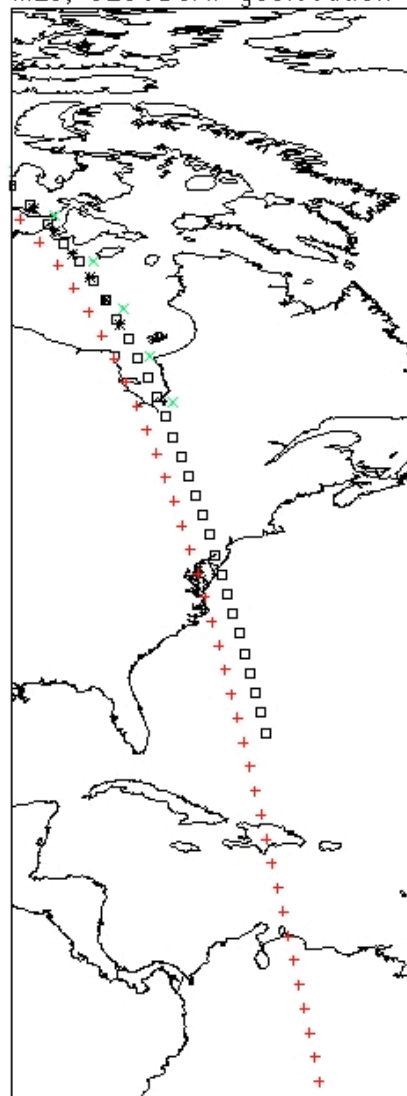
The purpose of the A-Train Data Depot is to:

- Facilitate A-Train science research by ...
- Provide multi-mission datasets that specifically fall on the A-Train formation flying path...
- Provide specific science research and applications services



AQUA, AURA, MLS, CLOUDSAT geolocation Feb 1st, 2006

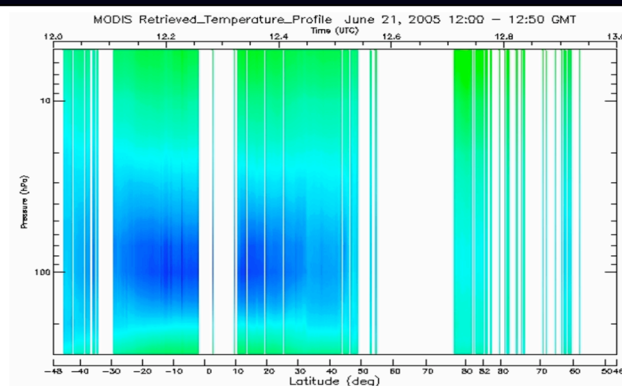
***** AQUA
+++++ AURA
□□□□□□□□ MLS
×××××××× CLDSAT



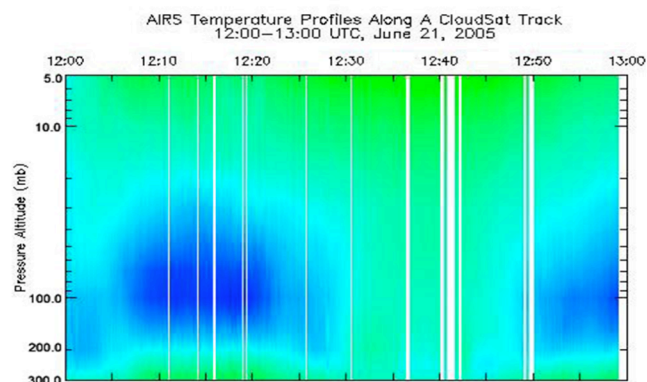


Example of AIRS-MODIS-MLS intercomparison

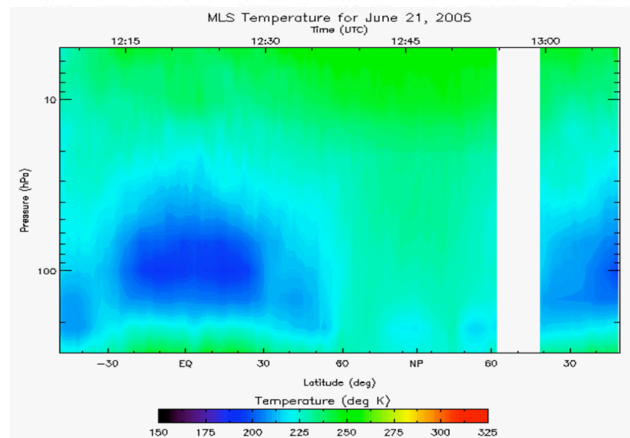
MODIS



AIRS



MLS



**MODIS--AIRS--MLS
Temperature “curtains”
along the CloudSat track**

300.0-5.0 mb

06/21/05

12:00 to 12:50 GMT

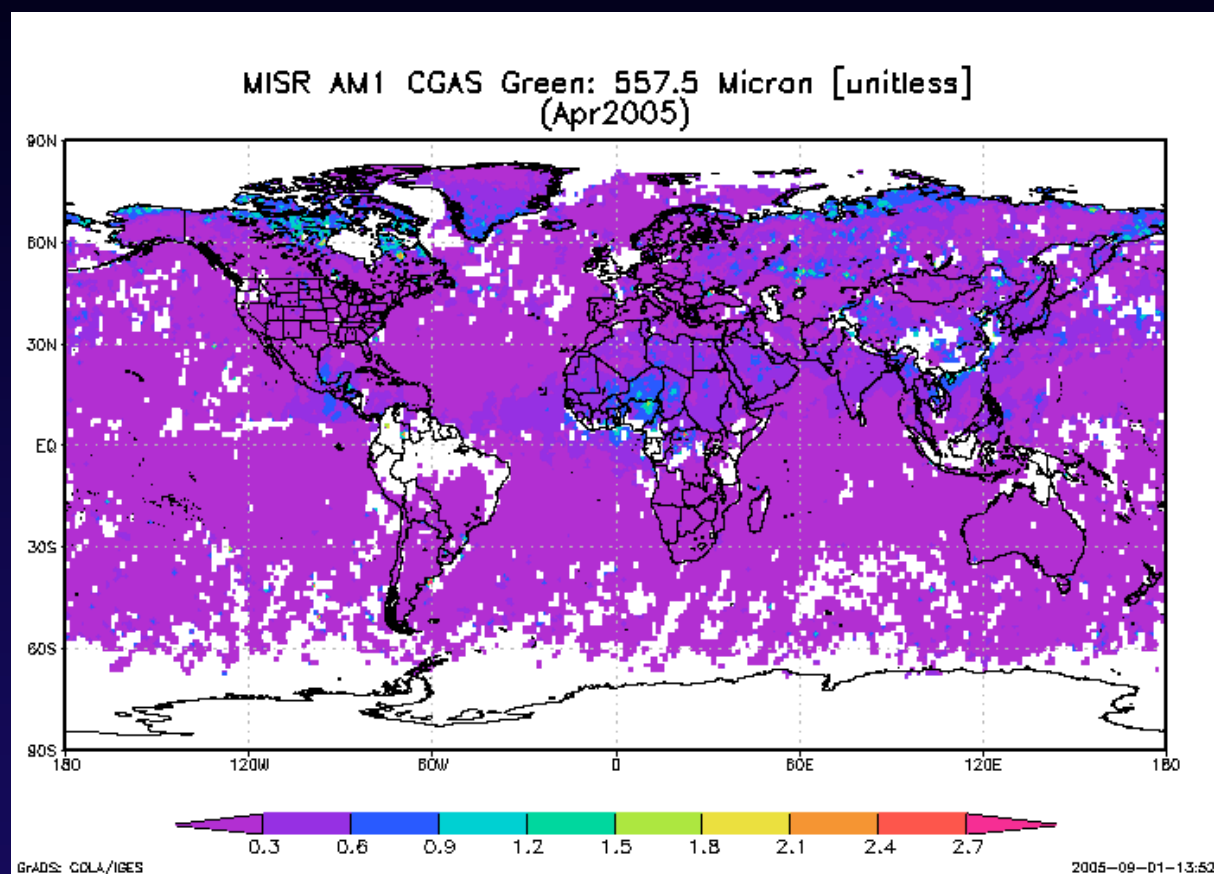
March 10, 2006

6, Pasadena

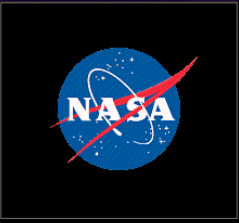
60



MISR in Giovanni?



Aerosol Optical Depth at 557.5 micron



TES in Giovanni?

Follow MLS model...



Future of Giovanni

- **Zonal Mean Cross-sections** (Parameter vs. Latitude e.g AOT, Total Ozone, Column Integrated Quantities)
- **Meridional Mean Cross-sections**
- **Polar/Hemisphere Stereographic Plots**(esp. for Total Ozone from various instruments)
- **Anomaly Plots** (Subtract Climatology, Seasonal Means, etc).
- **Spatial Correlation Plots**
- **CONSTRAINED** Scatter Plots (to make sense of the scatter!)
 - **Time-Altitude or Pressure Cross-Section** (AIRS, MLS)
 - **Zonal Mean Cross-Section Latitude-Altitude or Pressure** (MLS)



Conclusions

- Giovanni is useful tool for various studies using AIRS
- It is perfect for quick interactive multi-sensor visualization and analysis
- It is relatively easy to add parameters and functionalities to Giovanni
- For those planning multi-sensor studies and data fusion, Giovanni can provide the needed infrastructure



Feedback is welcome!